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THE BREEDING BIOLOGY OF FRANKLIN'S GULL

(*Larus pipixcan*)

by

© JULIAN WILFRED GUAY

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Breeding Biology of Franklin's Gull (Larus pipixcan)", submitted by Julian Wilfred Guay in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

A study of the breeding biology of Franklin's Gull, Larus pipixcan, was carried out in central Alberta during the breeding seasons of 1964, 1965 and 1966.

The previous year's emergent vegetation, Scirpus acutus or Typha latifolia, provides a foundation and the material for nest building. Preferred nesting sites are those nearest open water.

Laying began on May 12, 1965 and lasted 21 days, with the peak on May 22. The average laying interval between egg I and egg II was 2.35 days and between egg II and egg III was 1.96 days. The average clutch for areas of minimal disturbance was 2.16 and the average egg size was 36.07 by 51.92 mm. Laying of replacement clutches by adults and laying by gulls with immature plumage occurred.

Incubation lasted an average of 24.6 days, beginning with the laying of egg I and increasing in intensity with completion of the clutch. Both sexes shared in incubation duties, with an average shift of two hours and 39 minutes. The period of most rapid embryonic weight increase occurred between 6 days to 10.5 days; a doubling in weight occurred every $1\frac{1}{2}$ days. Chicks took an average of two days to emerge from the egg. Hatching commenced June 9, in 1965, lasted 17 days, and had its mean June 15. For all nests studied, two-thirds of the eggs did not hatch; of these, the greatest loss, 66 percent, was due to destruction by Franklin's Gulls. The reproductive success for the least disturbed areas was a hatching success of 1.69 and a fledging success of 0.34 young per clutch. The young require 30 days to fledge.

Disturbance by the author lowered reproductive success. Disturbance occurring during nest-marking was the most detrimental. Nest-marking dates just prior to the peak of laying or hatching showed the least

detrimental effects. Study areas of minimal disturbance had a 55 percent higher hatching success than areas of maximal disturbance.

The male reproductive tract was in a more advanced stage of development than was that of the female at the time of the adults' arrival at the breeding ground. Males tended to be larger than females for 14 external measurements. A "bill index" obtained by multiplying "bill length" times "bill depth at base" separated the sexes in the adult birds 80 percent of the time.

The bursa in the youngest adult Franklin's Gull appears to be larger than in older birds, decreases in size gradually as the bird ages, and finally disappears when the bird reaches maturity. Six wing classes based on the coloration of the two outermost primaries were distinguished for the adult Franklin's Gulls; confirmation of ages may demonstrate that maximal amounts of black coloration are associated with younger ages while minimal amounts are associated with the oldest adults.

Food items of the adults consisted of 88 percent Insecta, of which 45 percent were Coleoptera.

Average residues below a toxic level of Dieldrin and DDT, with its breakdown products DDD and DDE, were found in adults, young and eggs. No major differences in pesticide levels were found among adults, young and eggs. It appears that the residues are obtained on the wintering grounds and migration routes, since the levels tend to decrease during residence in Alberta. Residue levels in young birds found dead were slightly lower than those in live young. Interaction between pesticide levels and starvation may contribute to death in some young gulls.

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Financial assistance was provided by the Department of Zoology at the University of Alberta and the National Research Council of Canada.

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Frontispiece. Adult Franklin's Gulls flying over study area at Hay Lakes, Alberta. June 11, 1965.

INTRODUCTION

A study of Franklin's Gulls, *Larus pipixcan*, was conducted on colonies at Big Lake and Hay Lakes, Alberta during 1964, 1965 and 1966. The primary objective of this research was to expand the knowledge of the breeding biology of Franklin's Gulls so that a comparison could be made with various related old world gulls, particularly Black-headed Gulls, *Larus ridibundus*. The data available in the literature on this species is meager. The only extensive data on the breeding biology was contributed by Bent (1921), who gives a general description of the colony, construction and size of nests, size of eggs, feeding, plumages, and breeding and winter ranges. Other contributions were concerned with more specific aspects. Ridgeway (1919) gives a description of the plumages and several external measurements from five adult males and four adult females. Dwight (1925) gives several external measurements for 14 adult males and 12 females, but his primary concern is a description of the various plumages. Moynihan (1955) compares some of the behavior patterns of Franklin's Gulls with other species. He states that the aerial hostile behavior of Franklin's Gulls is similar to that of Ring-billed Gulls (*Larus delawarensis*) and hooded gulls, namely Laughing Gulls (*Larus atricilla*), Black-headed Gulls and Little Gulls (*Larus minutus*). The hostile displays of adult Franklin's Gulls on the ground or water are suggestive of Laughing Gulls. This is particularly true of the "Long Call" patterns (Moynihan, 1955). He also notes that the adult "non-aerial patterns" of Franklin's Gulls have homologues in those of Ring-billed Gulls. Rothweiler (1960) has some unpublished information on the nests of Franklin's Gulls but deals primarily with

food items of the gulls. He found the most abundant food item to be insects.

Several authors (Drost et al., 1961; Paludan, 1951; Tinbergen, 1953, 1959; Vermeer, 1963, 1967) have conducted studies of the breeding biology of four-cycle gulls, i.e. gulls which appear to require three or four years to reach sexual maturity. These gulls nest on the ground, mainly on islands. This is in sharp contrast to the floating nests constructed by Franklin's Gulls. The Black-headed Gull of Europe is a two-cycle species, i.e. normally requiring two years to attain sexual maturity. Franklin's Gulls also appear to be a two-cycle species. Requirements for nesting of these two species are very similar. Other data proved to be similar as well. For this reason, the author compared the data on Franklin's Gulls primarily with that on Black-headed Gulls.

Franklin's Gulls breed from the Canadian prairies south to Oregon (Malheur Lake), Utah (Great Salt Lake), northeastern South Dakota, and northwestern Iowa. They winter from Guatemala to Chile on the Pacific and on Caribbean Islands and Mexico on the Atlantic Ocean (A.O.U. Check-list, 1957).

To extend the data on the breeding biology of Franklin's Gulls, the following aspects were studied: habitat requirements, laying, incubation, growth of embryos, hatching, growth of the young, reproductive success, disturbance by investigator, gonadal cycle, sexual dimorphism, food and pesticide residues.

Various problems arose during the study. The first problem was the difficulty of movement by the author within the colonies. Heavy vegetative cover and shallow water precluded the use of a boat. Movement on foot was the only reasonable mode of travel. The very muddy bottom

(averaging approximately 18 inches deep) and the thick cover of vegetation produced a situation in which movement on foot was extremely difficult and time consuming.

The second major problem arose from the "shyness" of these birds. Marking of nests, eggs and daily checks of nests contributed to a high rate of abandonment. The initial field techniques utilized in 1964 at Big Lake accelerated the rate of abandonment. The colony at Big Lake was considered a transient colony (a result of the fluctuating water levels). The research was then relocated to a well established gull colony at Hay Lakes midway through 1964. Disturbance by the investigator was not established as the main factor influencing abandonment until 1965. In 1965, new field techniques were employed to minimize disturbance. Separate groups of nests were studied for different phases of the breeding cycle, i.e. laying, incubation and growth of the young.

The data for the thesis were selected from the nests subjected to minimal disturbance by the investigator. Only the sections entitled "Fate of Eggs" and "Effects of Investigator" include data from nests which were disturbed both minimally and maximally. Although some of the sample sizes were small, the author feels that the information presented on Franklin's Gulls is representative of the species in central Alberta.

METHODS

In 1964, newly constructed nests were located and marked with five feet long wooden stakes, the upper six inches of which were painted "international orange" to facilitate sighting. The stakes were numbered in black ink with a felt marking pen. Each stake was placed one foot northwest of the outer rim of the nest.

In 1965, unpainted, wooden stakes six feet in length were used. Several bundles of pre-numbered stakes were deposited at various locations throughout the study area prior to the arrival of the birds. This facilitated the marking of the nests and reduced abandonment by decreasing the total time spent in the area, and hence, decreasing disturbance of environmental conditions.

During three years, a total of 929 nests were marked. At Big Lake in 1964, 345 nests were arbitrarily divided by the author into seven study areas: A (71 nests), B (50), B' (5), C (82), D (30), E (81), and F (26). That same year at Hay Lakes, 61 nests were studied: area X (14 nests), W (36) and Z (11). Because it was thought that the high rate of abandonment at Big Lake in 1964 was due to the temporary nature of the colony, a sample was studied at Hay Lakes each of the following two years. In 1965, 392 nests were marked at Hay Lakes to validate the material from the previous year's 345 nests. These nests were arbitrarily divided by the author into six study areas: J (146 nests), U (32), L (75), M (64), G-N (36) and SP (39). That same year at that location, 76 nests were marked to compare with the results from the 61 nests in 1964. These were divided into study areas: 500 (22 nests), 600 (23), 700 (17) and 800 (14), (Fig. 1). In 1966, 42 nests were arbitrarily divided into

Fig. 1. Aerial photo of colony at Hay Lakes, Alberta with locations of the designated study areas. The numbers 5, 6, 7, and 8 represent fenced areas 500, 600, 700, and 800 respectively.


X
M
Z
W
GN
U
J
SP
7
5
8
6

four study areas: P (5 nests), Q (8), R (11) and AN (18). That year, 13 nests were marked for observation of incubating behavior. The nests were checked once daily in 1964. In 1965 and 1966, the nests were checked three times daily with the exception of study areas SP, 500, 600, 700, and 800. Transportation between groups of nests at one colony was by a small boat and motor. Movement within each group of nests was on foot.

As eggs were laid, they were marked with a felt marking pen. The eggs were marked with Roman numerals on two sides while they were lying in the nest. Only the tip of the pen touched the eggs. The eggs were not handled or disturbed in any other way. Laying intervals, construction of nests, loss of eggs and abandonment were recorded for the laying period.

In 1964, this information was recorded in a notebook. In 1965, the information was recorded on individual nest record cards, which were punched and put on a ring binder. The nest record cards speeded up the daily nest checking and the final analysis of the data.

Of the 345 nests marked in 1964 at Big Lake, 111 were checked through the incubation period to hatching. The remainder, because of abandonment, were not checked after May 31. Of the 392 nests marked in 1965, area SP, with 39 nests, was checked through the incubation period to hatching. The remainder of the nests were not checked after June 8 because of abandonment. Information, such as duration of the incubation period, loss of eggs, construction of nests and hatching success, was obtained from these 150 nests (111 plus 39 which were checked to hatching).

In 1964, 61 nests and in 1965, 76 nests, were fenced off at Hay Lakes during the incubation period. The fencing was required because young Franklin's Gulls do not appear to remain in the vicinity of the nest after two days of age (Fig. 2). The fenced areas in 1964, with their correspond-

Fig. 2. A fenced area for studying growth of young at Hay Lakes, Alberta. June 11, 1965.

ing number of nests were: X (14 nests), W (36), and Z (11); and in 1965: 500 (22 nests), 600 (23), 700 (17), and 800 (14). The fenced areas were circular in shape. The fence consisted of one-inch wire mesh, three feet in height, supported by two by two inch wooden posts about ten feet apart. The bottom of the mesh was submerged six inches below the water level. The nests within the fenced areas were marked with numbered lathes. The lathes were placed one foot northwest of the outer rim of the nests. Sizes of clutches, hatching success, growth rates of the young, mortality of the young and fledging success were recorded.

As the eggs hatched in the fenced areas, the young were banded with numbered, colored, expanding plastic leg bands. The plastic bands were later replaced with U. S. Fish and Wildlife aluminum leg bands when the young were recaptured. The young were weighed daily, to the nearest gram, with a Welch spring scale, until fledging or death.

In 1966, at Hay Lakes, the following areas were designated for the collection of known-aged embryos: P (5 nests), Q (8), R (11) and AN (18). Fifty-six eggs were collected individually at various stages of development, ranging from seven to 24 days of incubation. The embryos from each nest were designated A, B, and C, corresponding to eggs I, II, and III respectively. The breadth and length of each egg were measured with vernier calipers. The embryo was then extracted from the egg and the yolk sac removed. Embryos were preserved in 10 percent formalin. After preservation, embryos were blotted with absorbent paper to remove excess moisture and then weighed on a Mettler Type B-6 scale to the nearest 1/100 of a gram. As eggs were collected from the nests, they were replaced with eggs from an unstudied portion of the colony in order to test the acceptance and incubation of replacement eggs by the adults.

Also in 1966, at Hay Lakes, 13 nests were marked for observation. Adult incubating behavior was observed for a period of 12 days. The high, thick vegetative cover precluded the observation of a greater number of nests from a single observation point. From eight of these nests, one member of each pair was trapped on the nest and marked with various colors of paint. The length of incubation shifts on each of these nests was recorded by observation. All 13 nests were utilized to determine the rate of abandonment of the nests. Abandonment was recorded with reference to date of marking of nests, color-marking of adults and distance of nests from the blind. Measurements of distance between nests were taken with a 100-foot tape-measure. The nests were located from 18 to 73 feet from the blind. Direction of the nests from the blind was determined by a compass. Observations were conducted from a green canvas, roofed shelter, four by four by four feet. A pair of 7 by 50 binoculars and a 20-power spotting scope with a tripod were utilized for the observations.

During the breeding seasons of 1964, 1965 and 1966, 100 adult male gulls and 70 female gulls were killed, at a rate of about two of each sex per week. These birds were taken from an unmarked portion of the colony, about one-half mile from the study areas. Fourteen external measurements were taken on the birds in the hope of finding characteristics which would separate the sexes. Since some of the specimens were partially damaged, the total numbers of individual measurements vary. Measurements were taken with vernier calipers, except for larger measurements which were taken with a meter stick. All measurements are expressed in millimeters. A detailed description of the measurements may be found in Appendix I. Color patterns for the wing tips were recorded for each specimen. Among the coloring of the wing

patterns of the adult gulls, the author had hoped to find an age characteristic. According to Dwight (1925) and Godfrey (1966), only three age classes can be readily separated: the mature adult, the immature or one-year-old bird and the young of the year, referred to as juveniles (Figs. 3 and 4). In conjunction with age characteristics, 1,132 juvenal gulls were banded just before fledging at Hay Lakes in 1964. No banded birds were recovered at Hay Lakes in 1965 or 1966, hence no known-aged immature or adult birds were collected.

Birds were collected at one-week intervals throughout the breeding season of 1966. The esophagi, with their undigested food materials from 27 gulls, were preserved in 70 percent alcohol for food analysis. The volume of food, to the nearest cubic centimeter, was obtained by adding the food to a graduated cylinder, partially filled with water, and measuring the displacement of water. Food items were classified to family where possible.

The length of the left testis for adult males and the diameters of the pre- and postovulatory follicles for adult females were recorded to the nearest 0.1 mm. The oviducts were weighed on a Mettler Type B-6 scale to the nearest 1/100 of a gram. The length and width of the bursa of Fabricius, when present, were recorded for all birds.

In 1966, at Hay Lakes, 26 adult gulls were collected upon arrival at the colony. As well, 30 eggs, 26 living young, 26 dead young and 26 adults prior to departure from the colony were collected. These specimens were submitted to Dr. D. J. Ecobichon for pesticide residue analysis. Sample sizes were within the range recommended by the analyst. Upon collection, the birds and eggs were individually wrapped, first in newspaper, then in plastic bags, and frozen. They were packed in dry ice and

Fig. 3. Adult (top) and immature, or one-year-old, Franklin's Gull (bottom). June 23, 1965.

Fig. 4. Juvenal Franklin's Gull at fledging. July 10, 1966. The angle of the photograph does not allow a clear display of the terminal white band on the tail.

shipped by air to the veterinary college at Guelph, Ontario. The uropygeal glands, livers, brains, and gastrointestinal tracts were checked for Lindane, Heptachlor, Aldrin, Telodrin, Dieldrin, DDT, DDD, DDE, Endrin and Methoxychlor. The gas chromatographic method was used to analyze for these residues.

All major field techniques, plus the marking date, were examined to determine the influence of human disturbance on reproductive success.

Nest density was determined by measuring the area of four fenced study plots used in 1965 and counting the number of nests in each plot. A 100-foot tape-measure was used to determine the number of square feet per area. When peripheral nests were to be excluded from the fenced areas, the fence was placed an equal distance between the excluded nest and the nearest enclosed nest.

Estimates of dominant emergent vegetative cover were calculated at both Big Lake and Hay Lakes. This was accomplished by means of linear transects with a 100-foot tape-measure. A total of ten random transects were taken at each location. The transects were measured during May on the remaining previous year's growth. The coverage is given in percent and represents the number of feet on which the coverage was total.

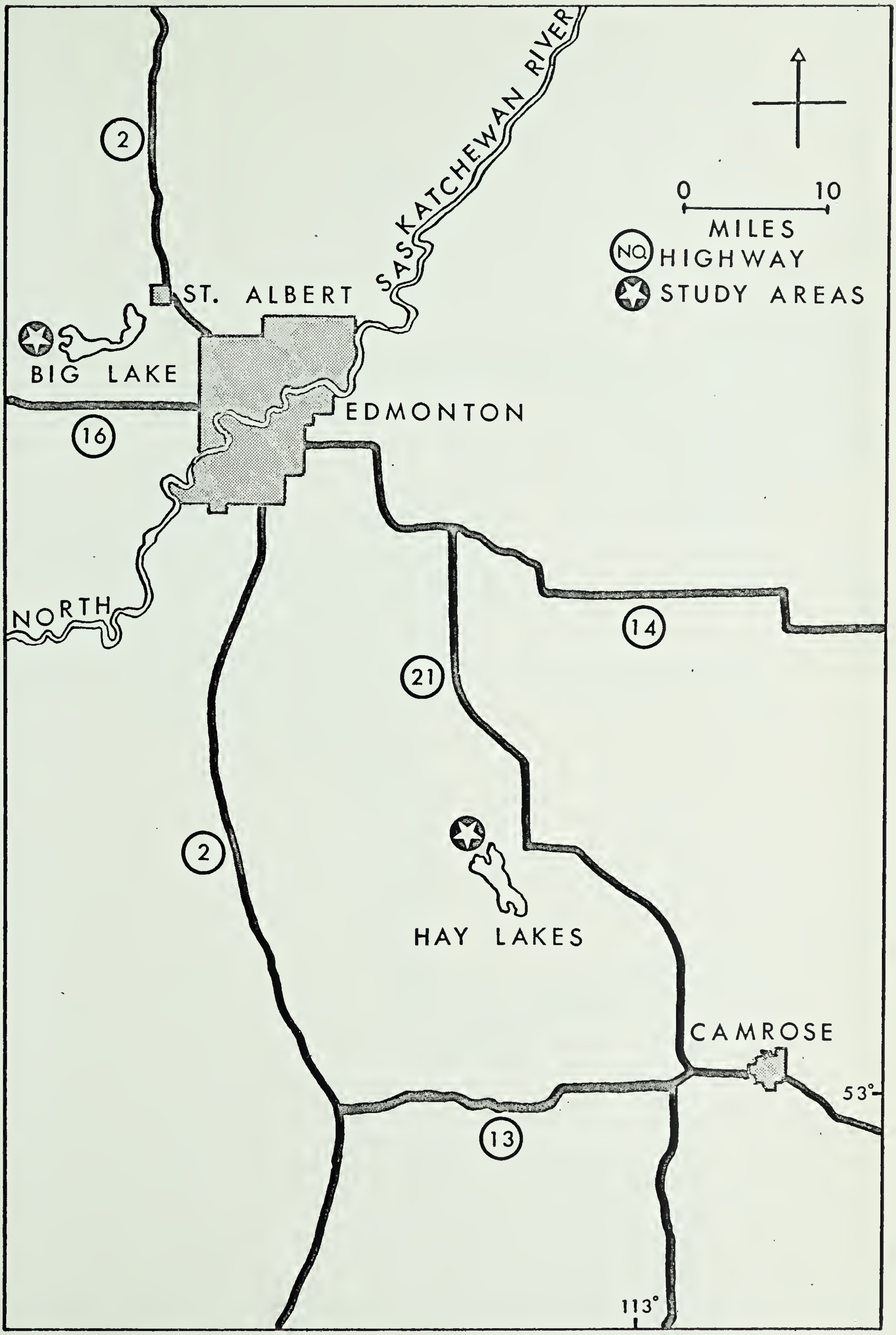
STUDY AREAS

The study areas were located in central Alberta in the aspen parkland. When conditions are normal, precipitation during the gulls' residence is relatively low, with monthly averages increasing from one inch to two and three-quarter inches from April through July. Bird (1961) describes the aspen parkland as containing two major plant communities, forest and grassland. They are intermingled with more or less solid stands of aspen and aquatic communities.

The Big Lake study area is near the town of St. Albert, 10 miles northwest of Edmonton, Alberta, Canada. The Hay Lakes study areas, near the city of Camrose, is approximately 30 miles southeast of Edmonton, Alberta (Fig. 5). The greatest proportion of the field research was carried out at Hay Lakes.

Big Lake has two inlets, Atim Creek and the Sturgeon River, and one outlet, the Sturgeon River (Fig. 6). The Sturgeon River inlet contributes to large fluctuations of the water level. During periods of high precipitation the Sturgeon River, which drains a large area, causes the lake to rise. It was for this reason that Franklin's Gulls did not nest at Big Lake during the summers of 1965 and 1966. The lake level was so high during these two summers that the emergent vegetation, cattail (<u>Typha latifolia</u>) and roundstem bulrushes (<u>Scirpus</u> sp.), was submerged, thus completely eliminating the gulls' nesting sites and destroying materials for construction of nests. Bent (1921) found that extreme conditions, i.e. a considerable reduction in the emergent vegetation, prevented Franklin's Gulls from nesting at a previously used location. As a result of the varying water level at Big Lake, the colony of

Fig. 5. Portion of central Alberta showing locations of study areas at Big Lake and Hay Lakes.



SASKATCHEWAN RIVER
0
10
MILES
NO.
HIGHWAY
STUDY AREAS
2
ST. ALBERT
BIG LAKE
EDMONTON
16
NORTH
14
21
2
HAY LAKES
CAMROSE
53°
13
113°

Fig. 6. Map of Big Lake, Alberta with locations of the designated study areas.

0
1
MILE
REEDS
STUDY AREAS
ATIM
CREEK
A
B'
B
C
D
E
F
BIG
LAKE
53° 35'
113° 45'

Franklin's Gulls does not appear to be well established.

The dominant emergent vegetation at Big Lake in 1964 was Typha latifolia, comprising more than an estimated 90 percent of the total vegetation, while much lesser amounts of Scirpus sp. occurred. The emergent vegetation at Big Lake in the areas adjacent to the Atim Creek inlet extends an estimated 50 yards back from the edge of the open water. The emergent vegetation encircling the slough location extended an estimated twenty yards from the shore to the edge of the open pools of water (Fig. 6).

Table I lists the other species of birds which were nesting within and adjacent to the gull colonies. No other species of gull was found nesting at Big Lake or Hay Lakes.

The gull colony at Big Lake in 1964 was estimated to contain 500 pairs of adult gulls. For this species, this is relatively small in size. Some Franklin's Gull colonies have been estimated at 40,000 birds (Bent, 1921).

The majority of gulls at Big Lake nested on the west side of the lake adjacent to an inlet, Atim Creek. Some gulls were nesting on the north side of this creek, but the majority were on the south side. Another colony was located encircling a slough which was located one-fourth of a mile west of the main lake shore and south of Atim Creek (Fig. 6). In all cases at Big Lake, the gulls were nesting in emergent Typha latifolia, which was utilized in the nest construction. The water depth in the nest areas averaged one foot. The deepest water in the lake in a normal year is three feet.

Hay Lakes, in contrast, has no natural inlet or outlet; but at the south end it does have a man-made drainage ditch that was constructed in 1957. The ditch varies from 4 feet to 5 feet in width and from 1

Table I. Species of birds found nesting within and adjacent to Franklin's Gull colonies at Big Lake and Hay Lakes, Alberta.

Species	Location Big Lake	Location Hay Lakes
Eared Grebe (*Podiceps caspicus*)		X
Canada Goose (*Branta canadensis*)		X
Mallard (*Anas platyrhynchos*)	X	X
Gadwall (*Anas strepera*)	X	X
Pintail (*Anas acuta*)	X	X
American Widgeon (*Mareca americana*)	X	X
Shoveler (*Spatula clypeata*)	X	X
Blue-winged Teal (*Anas discors*)	X	X
Green-winged Teal (*Anas carolinensis*)	X	X
Redhead (*Aythya americana*)	X	X
Lesser Scaup (*Aythya affinis*)	X	X
Canvasback (*Aythya valisineria*)	X	X
Ruddy Duck (*Oxyura jamaicensis*)	X	X
Sora (*Porzana carolina*)	X	
American Coot (*Fulica americana*)	X	X
Wilson's Phalarope (*Steganopus tricolor*)	X	
Black Tern (*Chlidonias niger*)	X	
Common Snipe (*Capella gallinago*)	X	
Long-billed Marsh Wren (*Telmatodytes palustris*)	X	X
Red-winged Blackbird (*Agelaius phoeniceus*)	X	X
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	X	X

to 2 feet in depth. It drains Hay Lakes into Bittern Lake which is three miles southeast. At the opening of the ditch in 1957, the lake level dropped two feet. Until the construction of the ditch, the gulls nested at the south end of the lake. In the spring of 1958, when the drop in water level reduced the quantity of emergent vegetation at the south end of the lake, the gulls moved to the north end. The colony was then located in the emergent vegetation off the end and on both sides of the point of land extending into the mid-north end of Hay Lakes (Fig. 7). The move was observed by Dr. C. G. Hampson (pers. comm.). To date, the gulls have nested at the north end of the lake. The operation of the drainage ditch maintained the water level at Hay Lakes at a relatively constant depth during the breeding seasons of 1964, 1965 and 1966. The colony at Hay Lakes dates back at least 40 years and appears to be well established. Farley (1932) estimated the Big Hay Lake colony to number 5,000 pairs in 1931. The colony remained relatively stable in size (2,000 pairs of adult gulls) throughout the study period.

Bent (1921) reported the water to be from two to three feet deep in a Franklin's Gull colony at Heron Lake, Minnesota in 1899. In Saskatchewan in 1905, he found water not over knee deep among Franklin's Gulls' nests. Rothweiler (1960) found the water level at Freezout Lake, Montana, to vary from zero to six inches among Franklin's Gulls' nests. The water under nests at Hay Lakes averaged one foot in depth. The water in the centre of Hay Lakes averaged three feet in depth. The depth of water is relevant mainly as a necessary condition for the growth of _Scirpus_ and _Typha_.

The primary emergent vegetation at Hay Lakes was _Scirpus acutus_ comprising an estimated 90 percent of the total vegetative cover. The remainder was mainly _Typha latifolia_. The gulls at Hay Lakes, unlike

Fig. 7. Aerial view of reed beds (center) used by nesting Franklin's Gulls at Hay Lakes, Alberta. August 8, 1966.

the colony at Big Lake, nest in Scirpus acutus and utilize this material for nest construction. The average extension of the emergent vegetation from the dry shore line to the edge of the open water is 100 yards. This extension of vegetation is interspersed with small open pools.

The variation in the density and height of the emergent vegetation is considerable at both colonies from the time the gulls first arrive until they depart. At arrival, only the previous year's growth exists and is bent over, broken, and does not conceal the nests. By the end of the incubation period, the new emergent vegetation is two to three feet above the water and is thick enough to conceal the nests. When the young gulls fledge, some thirty days later, the emergent vegetation is extremely high, averaging six feet above the water level. At this time it is difficult to traverse the area.

RESULTS AND DISCUSSION

Migration and Banding

Rowan (1928) banded 5,000 young Franklin's Gulls at Beaverhill Lake, Alberta. There appear to be no recorded recoveries.

DuMont (1941), who studied the localities where 96 Franklin's Gulls were recovered from 23,911 banded birds, emphasized the comparatively narrow migration route. These gulls follow a migration route that extends from the prairie provinces of Canada, southward through the Mississippi River Valley, through Mexico, Central America, to Peru on the western coast of South America.

Between June 16 to 18, 1964, 1,132 juvenal Franklin's Gulls were banded at Hay Lakes, Alberta. Only three recoveries have been received to date. The first gull was recovered August 4, 1964, at Bethune, Saskatchewan. The second recovery was from Manta, Ecuador, where the bird was captured November 25, 1964. The third recovery was from Lost Mountain Lake near Holdfast, Saskatchewan on July 6, 1965. These three recoveries of banded gulls would fit the migration route that DuMont (1941) described. Franklin's Gulls appear to migrate east from Hay Lakes to Saskatchewan, south along the Mississippi drainage to the southeastern coast of North America, then across the isthmus of Panama to the western coast of South America.

Arrival

Bergman (1939) found that Herring Gulls (Larus argentatus) and Lesser Black-backed Gulls (L. fuscus) did not occupy a colonial site located on islands in the Baltic Sea until the ice had melted. Unseasonably low temperatures and dull weather delayed the occupancy of a

colony of Herring Gulls on Graesholm Island in the Baltic (Paludan, 1951). Vermeer (1967) found at Miquelon Lake, Alberta that the arrival of the California Gull (*L. californicus*) and Ring-billed Gulls occurs before the ice has thawed. Ytreberg (1956) found the arrival date for Black-headed Gulls in Norway on the colony varied as much as two weeks in a period of three years.

The first appearance of adult Franklin's Gulls on the breeding grounds in central Alberta also varies from year to year. In 1964 and 1965, the author was unable to begin field work until after the gulls had arrived on the study areas. However, the first Franklin's Gull was seen in the Edmonton vicinity on April 20, 1964, by Mr. R. Lister (pers. comm.) and the first Franklin's Gull in 1965 was noted by Dr. K. Vermeer (pers. comm.) on April 24 at Miquelon Lake, 17 miles northeast of Hay Lakes.

In 1966, the author entered the field on April 15 and Franklin's Gulls were first seen at Hay Lakes on April 21. Only seven adult gulls were seen on this date. By the 25th of April approximately 60 adult gulls were seen. Finally on the 30th of April the majority of the gulls appeared to have arrived. The Franklin's Gulls arrived at the site of the colony at Hay Lakes in 1966 before the ice had thawed, indicating the occupancy of the colony does not depend upon the absence of ice.

Kirkman (1937) states that the Black-headed Gulls in England leave the colony during the evening in the pre-nesting period. Vermeer (1967) found that the gulls at Miquelon Lake, Alberta did not remain on the islands where nesting colonies were located during the night until after laying had started. Since no evening observations were made during the pre-nesting period at Hay Lakes or Big Lake, it is not known whether Franklin's Gulls leave the colony at night.

Construction of Nests

Ytreberg (1956) states that Black-headed Gulls' nests in early stages of construction were found throughout the colony during the early periods of nest construction, some never being completed. Sometimes materials disappeared from these nests or they were completed at a later date. He says that Black-headed Gulls may be occupied with nest-building throughout the entire breeding period. Ytreberg also observed Black-headed Gulls building new nests for the young, which he refers to as "plateaus." These new nests appear to be constructed following disturbance or destruction of previous nests.

Only general observations of construction of the nests in Franklin's Gulls were made during the pre-laying and laying periods. Construction of nests at Hay Lakes in 1966 was first noted on May 8, four days before the start of laying. The peak of construction of nests by these gulls was May 10, 1964 at Big Lake and May 9, 1965 at Hay Lakes, two to three days prior to the start of laying.

The time required for a Franklin's Gull to construct its nest varied from one to ten days, with an average of about three days. Many nests, started during the pre-laying period, were never completed. Some nests were gradually completed. Still others were constructed in a 24-hour period on a site where no previous nest had existed. Maintenance of the nest continued throughout the laying period, but to a much lesser extent than before laying began. Maintenance of the nest during incubation was quite infrequent; its primary purpose appeared to serve as an outlet for breeding behavior. Maintenance of nests after the young had hatched was almost non-existent in Franklin's Gulls. It was seen on only three occasions.

That Black-headed Gulls remove material from a neighbor's nest has been observed by both Kirkman (1937) and Ytreberg (1956). Franklin's Gull nests, partially contructed, then abandoned, most often became reduced in size as the material was taken for construction of nests elsewhere in the colony. Unattended nests were also susceptible to loss of material to other gulls throughout the colony.

Ytreberg (1956) has observed individual pairs of Black-headed Gulls building more than one nest. However, he states, "...it would appear that the birds which begin a nest are those which finish it and lay the eggs."

Although no specific pairs of adult Franklin's Gulls were observed building more than their first nest, the author feels that it probably does occur, partly based on the observation that there were more nests partially or completely constructed on the colonies than there were pairs of gulls present.

Kirkman (1937) feels that nesting material collected by Black-headed Gulls during incubation probably serves mainly as an outlet for "frustrated broodiness," while serving to a lesser degree to complete or maintain the nest. Ytreberg (1956) believes that the collecting of material by Black-headed Gulls during incubation has further significance in encouraging the brooding bird to leave the eggs, allowing its partner to take over incubation.

Rubow (1911) found that the female Black-headed Gull guards the nest site while the male obtains building materials. Kirkman (1937), from observations of three different Black-headed Gull pairs, found the male was the first to begin to build. Moynihan (1955) states it is evident that the male takes the initiative at the beginning of nest-building.

The male, he states, selects the nest site, collects the nest material and does most of the nest-building. Holstein (1935), Makatsch (1952a) and Noll (1924), on the other hand, believe that both members of the pair bring nest material separately and build the nest together. Ytreberg's (1956) investigations support Kirkman and Moynihan, stating that the male obtains the nest material and performs most of the construction. Since male and female Franklin's Gulls cannot be separated in the field, the sex most active in nest-building could not be identified.

Location of Nests

Farley (1932) mentions that notable changes had taken place in the nesting colonies of Franklin's Gulls in central Alberta during the twenty-five years prior to 1895. He states that a colony of ten thousand pairs of Franklin's Gulls nested on Spotted Lake, Alberta, but were later forced to seek a new nesting site as the lake was drained. He also mentions that another large colony nested (up until about 1929) at the southern end of Beaverhill Lake. When the water receded, the gulls were compelled to move to other locations on the lake. In 1905, a lake in southwestern Saskatchewan was occupied by a colony of approximately 20,000 pairs of Franklin's Gulls. One year later, because the lake was dry during the nest-building period, the lake was abandoned by the gulls (Bent, 1921). In 1963, the author visited a Franklin's Gull colony at Egg Lake, about 45 miles northwest of Edmonton. The lake appeared to be at a mean level. I located a colony along the southwestern edge of the lake populated by approximately 300 pairs of gulls. I revisited this same area in 1964 and discovered that the lake was completely dry. Not a single gull's nest was found.

The habitat in which Franklin's Gulls nest can vary considerably in quantity of vegetation, depending upon the conditions which prevail in the nesting area during the breeding season. The most critical prerequisite for a successful nesting site appears to be emergent vegetation, namely Scirpus acutus or Typha latifolia. If, at the beginning of a nesting period, the water level drops or rises to a point where the emergent vegetation is not available for nesting material, Franklin's Gulls will probably not nest at that location.

Black-headed Gulls prefer nests that are located as near to open water as possible (Collett, 1921; Herr, 1931; Stolz, 1911; Ytreberg, 1956). Makatsch (1952a), Ytreberg (1956) and Zimmermann (1927) deduced that the Black-headed Gull prefers nesting sites which are open on at least one side. Ytreberg (1956) feels that the demand for the nests by the edge of the open water is connected with good visibility.

Bent (1921) found in Saskatchewan in 1905, that the nests in a Franklin's Gull colony appear to be more abundant along the edge of the reedy area and open water. He further states that the "...nests in the outer edge of the reeds seemed to have been occupied first, as it was here that we found most of the young."

It was observed in the Hay Lakes colony in April of 1966 that the first gulls to take up territories selected those areas nearest the open water (Fig. 8). Open water is described as an area of at least two feet across. These areas appeared to be the preferred nesting sites. These sites included not only areas adjacent to open water on the main body of the lake lying along the edge of the reed bed, but open water scattered in small pools within the reed bed. Most of the nests were located within

Fig. 8. Nesting location with numbered stakes on study area at Hay Lakes, Alberta. June 11, 1965.

three feet of open water. Nest sites acquired after all the available primary sites were taken were located further from the open water. By the end of the first week in May most of the prime nesting sites had been acquired. A possible explanation for the preference of nesting sites along the reed edge, adjacent to the open water, is visibility. Gulls here would have excellent visibility in at least one direction, providing a good escape route from predators.

The Black-headed Gulls build their nests on areas where vegetation from the previous year has been bent or trampled down during the course of the winter (Ytreberg, 1956). The exact spot where Franklin's Gulls' nests were constructed varied somewhat but appeared to be associated primarily with the condition of the previous years' emergent vegetation. The majority of birds at Hay Lakes built the foundation of their nest on a clump of Scirpus acutus which was either bent over or broken over from the previous year. This type of foundation securely anchored the Franklin's Gull's nest. The nests usually float, but during conditions of heavy rainfall accompanied by a rapid rise in the water level the nests may become dismantled.

Both Holstein (1935) and Kirkman (1937) point out that the gulls build nests in larger or smaller groups. Salomonsen (1947) has asserted that several species of birds, including the Common Gull (Larus canus) frequently breed in the immediate neighborhood of Black-headed Gull colonies where they seek some form of protection, because the Black-headed Gull is very irritable and aggressive towards predators. The advantages of colonial nesting of gulls is mentioned by Kruuk (1964). He feels that proximity of nests in a Black-headed Gull colony produces many behavioral defense mechanisms

which decrease predation. He was able to demonstrate this experimentally from attacks on gulls' eggs by Carrion Crows (Corvus corone) and Herring Gulls. The reduction in predation on gulls' eggs was the result of flight responses to alarm calls and mass attacks on the intruding predator.

It was observed in 1966 at Hay Lakes that Franklin's Gulls, sociable birds, build nests in colonies, choosing secondary nesting sites in order to remain within the colony, rather than selecting primary nesting sites some distance from the other birds.

Material for Nests

Ytreberg (1956) states that Black-headed Gulls may build nests of many different types of material. The material used depends upon what is available in the colony area.

Bent (1921) describes a lake in Saskatchewan in 1905 (the location of a large Franklin's Gull colony) as having 200 or 300 yards of bulrushes, Scirpus lacustris, growing out from the shore. Here, the nest was constructed of the dominant vegetation (Scirpus lacustris). He also mentions a colony of Franklin's Gulls which were nesting in Scirpus spp. at Heron Lake, Minnesota in 1899. Here again, the nests were constructed of the same material. Rothweiler (1960) at Freezout Lake, Montana, found Franklin's Gulls' nests located in and constructed of dried bulrushes (Scirpus paludosus). Wolford in 1964 at San Francisco Lake and Scott's Reservoir in southern Alberta found Franklin's Gulls nesting in Scirpus spp. and constructing their nests of the same material.

At Egg Lake, in 1963, Franklin's Gulls' nests were constructed of the dominant emergent vegetation, Typha latifolia. At Big Lake, all nests that were found were constructed of the dominant vegetation,

Typha latifolia. At Hay Lakes, the dominant vegetation was *Scirpus acutus* and all gulls' nests found there were constructed entirely of *Scirpus acutus*. The material utilized in nest construction is the dominant emergent vegetation in the nesting area. The nest is built from the previous year's growth of this vegetation. The foundation consists of large, thick pieces and the material becomes progressively smaller in diameter toward the top of the nest. Only a small portion of the fine tips of new vegetation is utilized in lining the cup. This lining does not appear until well into the incubation period.

Density of Nests

Density of nests is represented as an average. Franklin's Gull nests have been located with a distance of only one foot between the outer rim of two adjacent nests. In this study, there appeared to be no variation in density with colony size. However, nests appeared closer together in the prime sites (as defined in an earlier section) as compared to the secondary sites.

In fencing particular study areas, the fence was placed on a line equidistant between the excluded nests and the nearest included nests which were located on the periphery of these areas.

It was found by measuring the fenced areas: 500, 600, 700 and 800, in 1966 at Hay Lakes, that the average density of nests was one nest per 80.7 square feet or a plot nine feet square per nest. Areas 500 and 600 were located on the edge of the open water, containing mostly prime nesting sites and areas 700 and 800 were located closer to the shore, containing mostly secondary nesting sites. The author feels that these four areas were representative of the whole colony. It can be

seen in Table II below that nests were more densely located in areas 500 and 600, and less densely located in 700 and 800. Density in the prime sites averaged one nest per 68.6 square feet and in secondary sites one per 100.5 square feet.

Table II. Density of nests of Franklin's Gulls.

Study Area	No. of Nests	Size of Area (sq. ft.)	No. Sq. Ft. per nest
500	22	1512	68.8
600	23	1575	68.5
700	17	1325	78.0
800	14	1725	123.0
Total	76	6137	
Average			80.7

<u>Size of Nests</u>

The nests of Black-headed Gulls can vary considerably in size and shape (Ytreberg, 1956). Kirkman (1937) writes, "It may be said with some truth that the size of a Black-headed Gull's nest is largely determined by the number of times it is prevented from sitting on its eggs."

Bent (1921) describes Franklin's Gulls' nests found in 1899 with a diameter at the water line of two to three feet and the top from eight to twelve inches above the water level. The cavity was found to be eight to ten inches in diameter and from three to four inches in depth. Bent (1921) found the diameter of other of these gulls'

nests to be from 12 to 30 inches and the nest built up from four to eight inches above the water. The cavity was slightly hollow and about five inches across.

At Hay Lakes, in 1965, 80 nests were measured. The nests varied from one to three feet in diameter at the water line (average 18 inches) and from four inches to fourteen inches above the water in height (average 8 inches). The cup of the nest where the eggs were laid and incubated was concave in shape, ranging from four to eight inches in diameter (average 6 inches) and one to four inches (average 2 inches) deep. The final result is a floating mound of dead reeds (Fig. 9). There appeared to be no relationship between the width and depth of individual nests nor between location on the colony and size.

Laying Period

Environmental conditions such as weather and abundance of food are important factors in the commencement date and duration of laying. Noll (1924) who made observations of the start of laying in Black-headed Gulls in Switzerland throughout a period of nine years found a maximum variation of 14 days. He found a relationship between the start of laying and the temperature in April. Kirkman (1937) found differences up to 13 days in the start of laying for these gulls in England. Unusually cold weather in 1913 resulted in an extremely late start of laying. In Germany Makatsch (1952a) found a maximum variation of the start of laying in Black-headed Gulls to be 13 days. Ytreberg (1956) states, "It would be reasonable to regard the weather - and primarily the temperature - as a controlling factor influencing egg-laying dates."

Goodbody (1955) found the mean date for completion of clutches was

Fig. 9. A nest and eggs of Franklin's Gulls at Hay Lakes, Alberta. June 8, 1965.

nine days earlier in one colony of Black-headed Gulls than another during the same breeding season. He believes the differences were a result of nesting site conditions rather than weather, since the colonies were located extremely close to one another and subject to similar weather conditions.

Paludan (1951) found postponed laying for Herring Gulls in 1947 which he traced indirectly to weather conditions. Bergman (1939) found that arrival and laying in Herring Gulls and Common Gulls depended upon the melting of the ice, not directly upon air temperatures in Finland.

At Miquelon Lake, Alberta, Vermeer (1967) found mean laying dates for Ring-billed Gulls and California Gulls that were 2.4 and 3.7 days earlier respectively in 1964 than in 1965. He found for these same species that approximately 75 percent of the initial clutches were laid within the first 9 days of the laying period. He feels the earlier laying means in 1964, as compared to 1965, were probably a result of the weather conditions. Minimal snow cover produced an abundance of food much earlier in 1966, however laying did not begin earlier for Ring-billed or California Gulls.

Wolford (1966) found the laying period in 1964 preceded that in 1965 by about a week for Black-crowned Night Herons (Nycticorax nycticorax) laying in southern Alberta.

Rothweiler (1960) found the first Franklin's Gull egg in 1959 at Freezout Lake, Montana, on May 20. This is later than would be expected since temperature and light conditions tend to be more favorable in more southerly locations. Jim Wolford (pers. comm.) found the first Franklin's Gulls' eggs at San Francisco Lake in southern Alberta on May 14, 1964. He found that the laying period for initial clutches lasted until

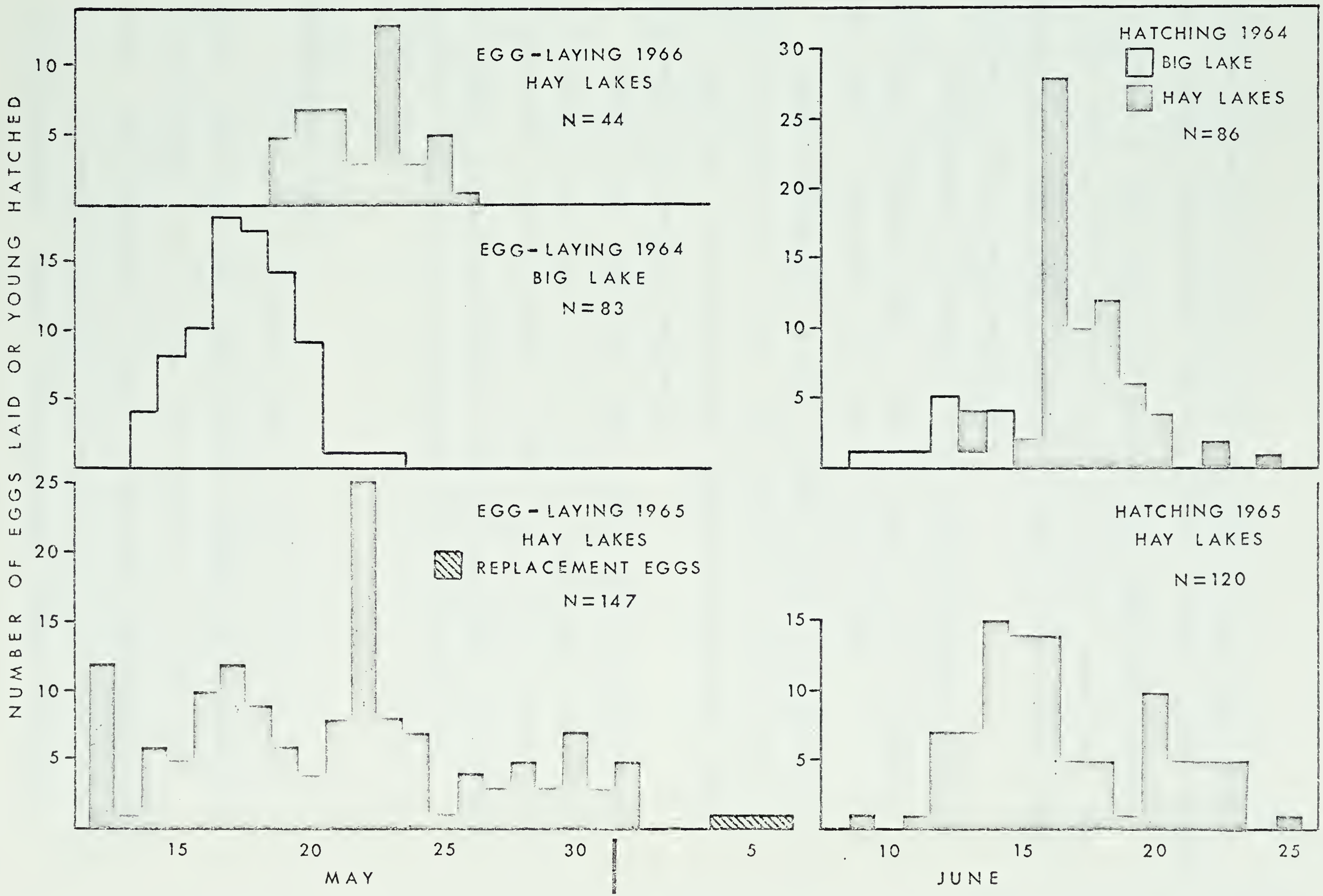
June 1, 1964, a period of 19 days. If Wolford's data can be considered significant, the laying period for Franklin's Gulls in southern Alberta as compared to central Alberta appears to start one day later and to be two days shorter in duration.

The mean dates of laying for 1964 at Big Lake, and 1965 and 1966 at Hay Lakes were May 18, May 21 and May 22 respectively for Franklin's Gulls (Fig. 10). Eggs had been laid prior to the first dates given on the graph for Big Lake, 1964 and Hay Lakes, 1966. The most complete graphical representation for the start and duration of laying is given for Hay Lakes, 1965. In 1964, at Big Lake, the first three nests, with a single egg each, were found on May 13; the following day, May 14, the author began marking nests and eggs. This latter date is represented as the beginning of the graph. The graph for Hay Lakes, 1966, shows only the central period of laying; it does not show the start or the length of laying. These nests in 1966 were marked for the purpose of obtaining 56 known-age embryos.

The first eggs to be found and marked at Hay Lakes in 1965 were discovered on May 12. The final egg from initial clutches was laid on June 1, 1965. The length of the laying period for initial clutches was 21 days in 1965. That year at Hay Lakes 25 percent of the initial clutches for Franklin's Gulls were laid by May 17, 50 percent by May 21 and 75 percent by May 24. This indicates that over half of the initial clutches were complete in the first nine days of the laying period and three-fourths complete within 12 days.

If we compare the mean laying dates for 1964, 1965 and 1966, we see that the mean for 1965 and for 1966 are essentially the same, May 21 and 22 respectively. However, the laying mean in 1964 on May 18 was three

Fig. 10. Frequency of laying and hatching in a population of Franklin's Gulls at Big Lake in 1964 and Hay Lakes, Alberta in 1964, 1965 and 1966. Samples for 1966 represent only a portion of the laying period.



EGG-LAYING 1966
HAY LAKES
N=44
EGG-LAYING 1964
BIG LAKE
N=83
EGG-LAYING 1965
HAY LAKES
REPLACEMENT EGGS
N=147
HATCHING 1964
BIG LAKE
HAY LAKES
N=86
HATCHING 1965
HAY LAKES
N=120
NUMBER OF EGGS LAID OR YOUNG HATCHED
MAY
JUNE

to four days before the means in 1965 and 1966. The mean laying date in 1964 probably preceded that of 1965 and 1966 as a result of milder weather conditions in 1964 (Table III). The mean daily temperatures for April in 1964, 1965 and 1966 were 40.7°, 36.6° and 33.0° F. respectively. The number of days with freezing temperatures in May for 1964, 1965 and 1966 were zero, four and seven respectively.

The appearance of food may be a factor which influences the start of laying in Franklin's Gulls. Since food samples were collected in 1966 only, no comparisons can be made with 1964 and 1965.

Human disturbance by the author probably did not contribute to a later mean laying date in 1965. Human disturbance appeared greater in 1964 than 1965. Field techniques were improved and became less time-consuming as the research progressed.

Vermeer (1967) and Wolford (1966) indicate earlier laying periods for California and Ring-billed Gulls and for Black-crowned Night Herons in Alberta in 1964 when compared to 1965. Their studies together with the author's and earlier findings of others would suggest that weather, primarily temperature, was the predominant factor influencing the laying periods.

Replacement Clutches

The laying of replacement clutches in gulls is well documented. Paludan (1951) found when 35 Herring Gull clutches were destroyed by a snowstorm most of the clutches were replaced 11 to 12 days later. Vermeer (1963) found that the Glaucous-winged Gulls (Larus glaucescens) nesting in a coastal environment can renest as late as one month after hatching has begun. Vermeer (1967) removed many clutches of both Ring-

Table III. Weather records for periods of research during 1964, 1965 and 1966.*

Date Location	TEMPERATURE (degrees F.) Mean Max.	Mean Min.	Mean Daily	Diff. from norm.	Max./ Date	Min./ Date	No. days freez.	PRECIPITATION (inches) Tot. Amt.	Diff. from norm.	No. days .01+	Heav- iest fall	Date	Snow- fall	No. days snow
April, 1964														
Edm.Ind.A.+	51.4	29.9	40.7	1.1	75 29	18 6	22	0.75	-0.35	6	0.38	4	2.3	4
Camrose								0.99		6	0.63	1	0.6	1
May, 1964														
Edm.Ind.A.	61.8	41.8	51.8	0.1	77 20	35 10	0	2.14	0.32	12	0.53	4	0.0	0
Camrose	62.8	40.6	51.7	1.0	77 19	34 15	0	3.21	1.57	10	1.27	20	0.0	0
June, 1964														
Edm.Ind.A.	69.6	49.6	59.6	1.7	82 27	43 22	0	1.04	-1.93	12	0.22	24	0.0	0
Camrose	68.6	47.4	58.0	1.0	80 27	40 2	0						0.0	0
Camrose								0.87		13	0.21	17	0.0	0
July, 1964														
Camrose	75.9	52.5	64.2	1.4	93 12	42 28	0	1.90	-0.77	13	0.66	9	0.0	0
April, 1965														
Camrose	45.5	27.6	36.6	-1.9	74 27	14 1	22	1.23	0.15	6	0.56	9	3.4	4
May, 1965														
Camrose	61.2	39.6	50.4	-0.3	75 27	28 18	4	3.90	2.26	13	1.78	16	0.0	0
June, 1965														
Camrose	66.0	47.2	56.6	-0.4	87 11	38 22	0	5.51	3.26	10	1.54	26	0.0	0
July, 1965														
Camrose	74.3	53.5	63.9	1.1	89 27	44 1	0	2.22	-0.45	16	0.46	7	0.0	0
April, 1966														
Camrose	42.9	23.1	33.0	-5.3	61 5	9 19	27	0.72	-0.27	8	0.40	9	1.0	1
May, 1966														
Camrose	66.7	38.8	52.8	1.7	87 26	28 1	7	1.23	-0.35	9	0.34	30	0.0	0
June, 1966														
Camrose	66.3	43.8	55.1	-1.8	81 16	34 6	0	1.94	-0.59	9	0.53	9	0.0	0
July, 1966														
Camrose	72.4	51.8	62.1	-0.5	84 15	42 4	0	2.54	-0.20	14	0.62	2	0.0	0

*Monthly Record, Dept. of Transport, Meteorological Branch, Canada.

+Edmonton Industrial Airport.

billed and California Gulls at Miquelon Lake, Alberta to test the extent of repeat laying four weeks after the beginning of laying. One California and one Ring-billed Gull each began a replcaement clutch. However, no other clutches were laid after the first week in June.

Ytreberg (1956) discovered three pairs of Black-headed Gulls in Norway that had each laid replacement clutches in 1952 and five pairs with replacement clutches in 1953. He also found that most replacement clutches were laid 10 to 11 days after the mean laying dates. This is similar to Franklin's Gulls.

Three replacement clutches were laid, as revealed by inspection of the ovaries of 68 female Franklin's Gulls collected at Hay Lakes, one in 1965 and two in 1966. They were not begun until two days after the initial laying was completed and twelve days after the peak. Other replacement clutches in the gull colonies probably occurred in other breeding seasons, but were not discovered.

The capacity of gulls to renest appears to vary from species to species and is probably dependent upon the habitat. Nests located in a region which has longer periods of favorable weather (such as coastal areas) and an abundant food supply (which may be more conducive to renesting) would have a greater probability of being replaced (Paludan, 1951; Vermeer, 1963).

Laying by Immatures

Haverschmidt (1931), Kirkman (1937), Noll (1931), Oordt (1934) and Rosenius (1942) have observed Black-headed Gulls with immature plumage breeding in Switzerland, Holland, England and Sweden. Noll (1931) found only females, and Ringleben (1940) mentions that nearly all examples of Black-headed Gulls proven capable of reproduction before acquiring adult plumage have been females. However, Lange (1928)

and Stadie (1929) found small brood patches on a male in first-year plumage. Mayaud (1941) reported that female Black-headed Gulls with first-year plumage were observed breeding. Ytreberg (1956) found seven cases of both male and female Black-headed Gulls with immature plumage breeding in Norway. He believes Black-headed Gulls, like Franklin's Gulls, normally require two years to become sexually mature.

Johnston (1956) found that there was a predominance of male California Gulls which were more sexually precocious than were females.

According to all the information available, Franklin's Gulls are unable to reproduce until they are two years of age. During the research period, a total of 15 immature gulls were collected at various times of the breeding season and adjacent to nesting sites. In 1964, one female from Big Lake and in 1966, one female from Hay Lakes, both with immature plumage (one-year-old), but sexually mature, were collected. These birds had both laid normal clutches, as revealed by an inspection of their reproductive tracts. Both birds had enlarged oviducts and three postovulatory follicles, the largest of which measured 5.0 and 3.4 mm. in diameter. One male with immature plumage, but sexually mature (length of left testis measured 11.1 mm.), was also collected in 1964 at Big Lake. No gulls with immature plumage were observed copulating, laying or incubating. Several immature birds were seen flying over the nesting areas at various times. It appears that immatures spend the breeding season on lakes where no breeding colony exists. At Sandy Lake, Alberta in June, 1963, 23 of these birds were observed and three collected and found to be sexually immature.

There is evidence for sexual maturity in gulls with immature plumage, but the relative incidence seems small and seems to occur in

either sex.

Laying Interval

Holstein (1935) states that it is most probable that Black-headed Gulls normally lay in the early hours of the morning. Goodbody (1955) is of the opinion that Black-headed Gulls can lay at any time of the day or night. Ytreberg (1956) claims fewer eggs in Black-headed Gulls are laid during the night than the day, most being laid in the morning and afternoon. He found in 1960 that the largest percentage of eggs were laid from noon to 8:00 p.m. Herring Gulls (Goethe, 1937) and Lesser Black-backed Gulls (Paludan, 1951) also may lay at any time of the day or night. Makatsch (1952b) states that Common Gulls lay practically all their eggs during the evening hours. Barth (1955), on the other hand, found that the same species may lay at any time of the day or night. I found that most Franklin's Gulls' eggs were laid during the afternoon, from 1:00 to 6:00 p.m., occurring in 60 percent of the cases.

It has been shown in other gull species that the laying interval between the first egg and second egg is essentially the same as between the second and third egg. Drent (1967) obtained an average laying interval in Herring Gulls of 48.7 hours. Other average laying intervals are: Herring Gulls, 48.4 hours (Paludan, 1951); Common Gulls, 47.8 hours (Barth, 1955); Black-headed Gulls, 40.3 hours (Weidmann, 1956) and 42.0 hours (Ytreberg, 1960). For Franklin's Gulls, I obtained an interval of 48.3 hours for eggs I and II and one of 47.4 for eggs II and III.

Ytreberg (1956) obtained a mean laying interval in Black-headed Gulls between eggs I and II of 1.8 days and 1.7 days between eggs II

and III. He found the laying interval was two days for 71.2 percent of the intervals between eggs I and II and for 64.1 percent between eggs II and III. Vermeer (1967) obtained a mean laying interval of 1.9 days between eggs I and II and 1.1 days between eggs II and III for California Gulls. He found the corresponding intervals for Ring-billed Gulls were 1.9 and 1.9 days.

The greatest proportion of Franklin's Gull data from Table IV was collected in 1965. The data for 1964, 1965 and 1966 were not significantly different, therefore they were all included in a single table. In 1964, nests were checked only once a day, at 8:00 a.m., allowing an error in the laying interval between eggs I and II of ± 24 hours. All nests in 1966 and in five study areas out of six in 1965 were checked three times daily, at 8:00 a.m., 1:00 p.m., and 6:00 p.m., allowing a maximum error of ± 14 hours for the interval between eggs I and II. Since, the greatest percentage of eggs were laid between 1:00 p.m. and 6:00 p.m., the most frequent error in the laying intervals between eggs I and II is ± 5 hours. The error is twice as great between eggs II and III as between eggs I and II.

From Table IV it will be noted that the interval between eggs I and II had a range of one to seven days, a mean of 2.35 (± 0.15) days and a mode of two days (occurring in 44 out of 55 cases). A total of 80 percent of the intervals between eggs I and II were two days long. The interval between eggs II and III, as shown in Table IV, has a range of one to three days, a mean of 1.96 (± 0.10) days and a mode of two days (occurring in 19 out of 26 cases). The interval between eggs II and III is two days for 73.1 percent of the cases. The laying interval for an entire clutch, eggs I to III, has a range of three to seven days and a mean of 4.08 (±0.3) days.

Table IV. Time intervals between laying of successive eggs and between first and last egg in Franklin's Gulls.*

Interval in days†	No. of cases I-II	II-III	I-III	Percent I-II	II-III	I-III
1	2	4		3.6	15.4	
2	44	19		80.0	73.1	
3	5	3	4	9.2	11.5	30.8
4			6			46.1
5	2		2	3.6		15.4
6						
7	2		1	3.6		7.7
Total	55	26	13	100.0	100.0	100.0
Mean	2.35	1.96	4.08			
S. E.	± 0.15	± 0.10	± 0.30			

*Data obtained from areas of minimal disturbance in 1964, 1965 and 1966.
†Interval began at 8:00 a.m.

Description of Eggs

The size of 48 Franklin's Gulls' eggs in the Unites States National Museum collection showed a mean length of 52.0 mm. with a range from 47.5 mm. to 56.5 mm. The mean width was 37.0 mm. with a range from 34.0 mm. to 38.5 mm. (Bent, 1921).

Measurements of 86 eggs by the author showed the mean length to be 51.9 mm., with a range from 47.7 to 56.8 mm. The mean width at the widest point was found to be 36.1 mm. with a range from 31.8 to 38.7 mm.

The eggs are olive in color marked with large and small blotches, that range in color from dusky brown to black (colors according to Palmer

and Reilly, 1956).

Incubation Intensity

Kirkman (1937) states that two stimuli necessary to initiate brooding are the nest and the egg. Without the egg, "incubation-like" behavior will be minimal. Paludan (1951), who shifted several Herring Gull eggs from one nest to another so that they were always in nests in the laying phase, produced embryos considerably smaller than eggs which had undergone normal incubation. Ytreberg (1956) is of the opinion that brooding is inefficient during the laying period. He states that brooding starts the day the first egg is laid and increases in intensity until the clutch is complete. Upon conclusion of laying, attentiveness continues at a relatively high degree. As proof, he cites the average development times for Black-headed Gull embryos in eggs I, II and III being 24.9, 23.6 and 22.8 days respectively. Egg I requires an average of 2.1 days and egg II requires 0.8 days longer to develop than egg III. Beer (1962) showed that the brood patches on Black-headed Gulls were not fully formed at the time the second egg was laid, thus preventing the gulls from attaining maximal brooding efficiency. Drent (1967) found, from the observation of 26 Herring Gulls' nests, that incubation attentiveness rose gradually over most of the incubation period, then declined toward the end of the period. As expected, Drent (1967) found incubation by Herring Gulls to be much more intense during periods of rainfall and low temperature. Vermeer (1967) found that for California Gulls only 26 and 51 percent of full incubation effectiveness was achieved after the laying of the first and second eggs respectively.

Incubation in Franklin's Gulls begins upon the laying of the first

egg, as reflected by weight increase of the embryo, as discussed in that section. The weight of the three embryos A, B, and C is similar despite the fact that embryo A has been incubated longer than embryo C. The hatching time between successive young within a nest closely approximates the laying interval of two days. The result from the hatching time between successive young, based on 39 nests, was 2.4 days. The reason this does not correspond directly to the laying interval is the varying degree of attentiveness during the laying period. Attentiveness increases as egg II is laid and reaches its full intensity by the time the third egg is laid. Once the entire clutch has been laid, the attentiveness remains high. The increase in attentiveness after the final egg has been laid is revealed by the smaller range of duration of incubation for egg III as compared to that for eggs I and II.

Incubation Shifts

Goodbody (1955) found that with Black-headed Gulls, very short brooding shifts occurred with exceptionally "nervous" birds that left their nests at the slightest alarm. Ytreberg (1956) found that the same species in the initial stages of brooding will stand up quite frequently to turn the eggs. This most frequently happens during intervals of only a few minutes and may also occur at a change of shift. Tinbergen (1953) states that Herring Gull eggs are also turned "after settling on the eggs, if the tactile stimulus is abnormal."

Ytreberg (1956) states that in Black-headed Gulls the normal brooding shifts seem to lie between one to two and one-half hours, and are shared almost equally by males and females. Drent (1967) observed that Herring Gulls incubate both day and night. He found that both male and female

gulls shared incubation duties equally with a shift lasting as long as 272 minutes, with 75 percent less than 40 minutes in length and an overall mean shift of 24.7 minutes. Shifts were found to be longer at night and shorter during the day.

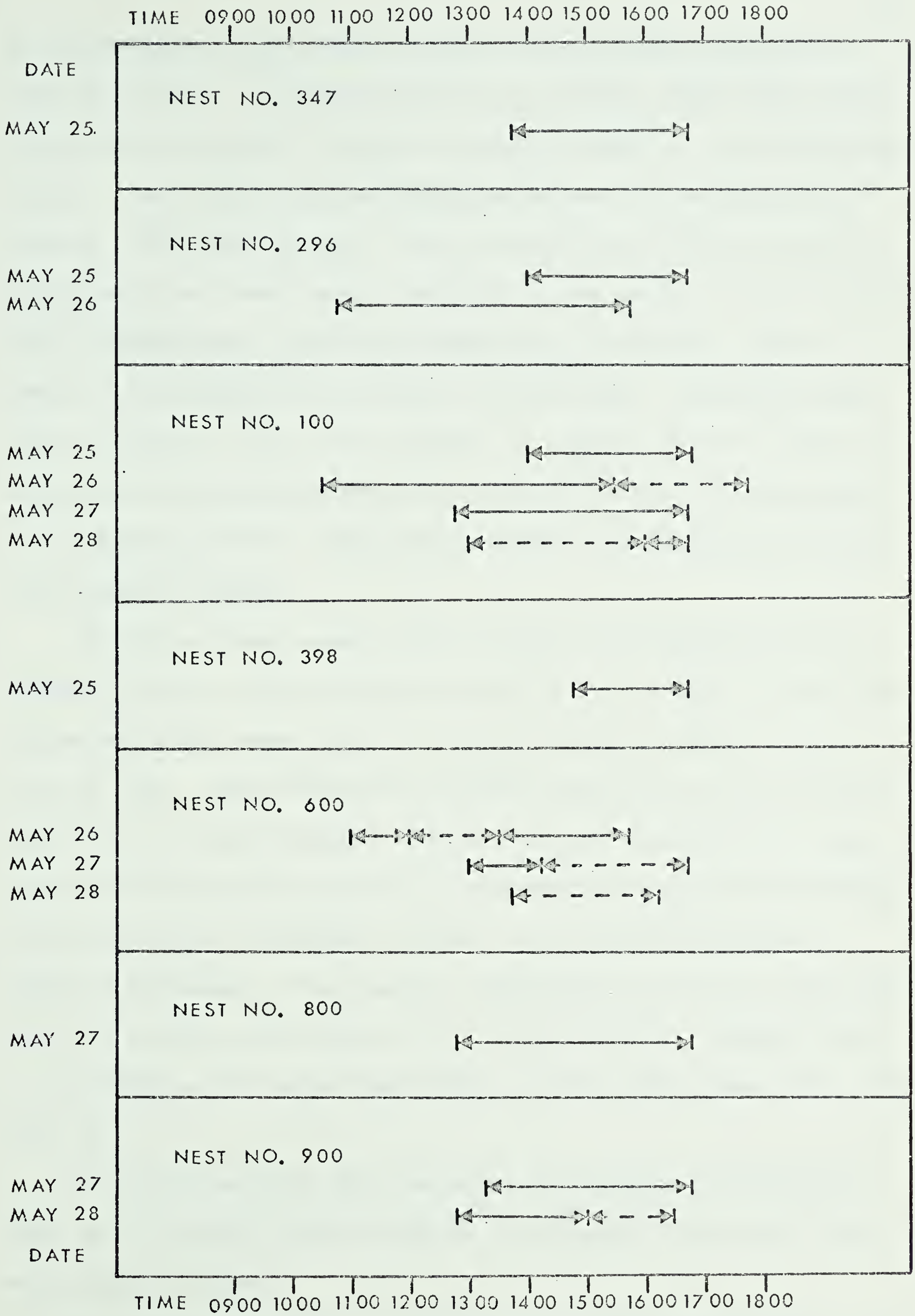
Bent (1921) believes that both sexes of Franklin's Gulls incubate. Shown in Fig. 11 are 20 complete incubation shifts for Franklin's Gulls which were obtained from May 22 to June 2, 1966, at Hay Lakes. Shifts which were in progress when the observer arrived or departed each day were considered incomplete and not recorded. The observations were carried out on a special observation area from a canvas blind. The total number of nests in this area was 13. Eight of the nests had one adult color-marked to aid in identification. Both male and female Franklin's Gulls incubate, but the sexes could not be separated during the observations.

Most incubation shifts in Franklin's Gulls were found to vary from 45 minutes to five hours, with an average of two hours and 39 minutes. Shorter incubation shifts do occur, lasting only a few minutes. These especially occur at the beginning of laying, during ideal weather conditions, and as a result of disturbance. These short incubation shifts are infrequent and do not appear to represent the average shift. The incubation shift durations for Franklin's Gulls under normal conditions seem similar to those of Black-headed Gulls.

Length of Incubation

Barth (1952, Paludan (1951) and Swanberg (1950) refer to the incubation period as the time which elapses from the laying of an egg

Fig. 11. Twenty incubation shifts of Franklin's Gulls. The solid line represents one member of an adult pair while the broken line represents its mate. Only complete shifts are shown.



TIME 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800
DATE
NEST NO. 347
MAY 25.
NEST NO. 296
MAY 25
MAY 26
NEST NO. 100
MAY 25
MAY 26
MAY 27
MAY 28
NEST NO. 398
MAY 25
NEST NO. 600
MAY 26
MAY 27
MAY 28
NEST NO. 800
MAY 27
NEST NO. 900
MAY 27
MAY 28
DATE
TIME 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800

to the emergence of the young from that egg and usually calculated on the last egg laid. In Black-headed Gulls, Ytreberg (1956) found incubation periods to be 24.9, 23.6 and 22.8 days for eggs I, II and III respectively. Drent (1967) obtained incubation periods for Herring Gulls as follows: 30.05 days for egg I, 28.40 for egg II and 27.16 for egg III. Both Ytreberg and Drent found a reduction in the length of the incubation period between eggs I and II and between eggs II and III. This is a result of the intensity of incubation during laying. Incubation begins upon the laying of egg I, but increases in intensity with the laying of egg II, reaching and maintaining its maximum intensity with the laying of the complete clutch. This point is further discussed in the "Incubation Intensity" section.

Jim Wolford (pers. comm.) found in 1964 at San Francisco Lake in southern Alberta a total of eleven Franklin's Gull clutches in which the incubation period ranged from 21 to 25 days, with an average of 23.5 ($\pm$ 0.33) days. This average from southern Alberta is one day less than that found in central Alberta. Perhaps this may be explained by higher temperatures and lesser amounts of precipitation (the latter only during the laying period) in southern Alberta, which are more favorable to embryonic development. Mean maximum temperatures for Brooks, Alberta for May, June and July, 1964 were 64.4°, 71.4° and 81.3° F. Average inches of precipitation for these three months at this location were 1.99, 1.62 and 1.85.

Bent (1921) mentions that the period of incubation in Franklin's Gulls is "...probably 18 to 20 days." No indication of how this figure was obtained is given.

The incubation periods in Franklin's Gulls were determined from the

time each egg was laid. Table V shows 80 incubation periods in Franklin's Gulls, varying from 21 to 28 days. The shortest incubation period occurs in egg II, 21 days, the longest occurs in egg I, 28 days. The range of the incubation period for egg III is much less than that for eggs I or II, being 24 to 27 days. This narrow range may be the consequence of a small sample or of increased attentiveness upon termination of laying the complete clutch. The average incubation periods for eggs I and II are almost equal, 24.6 ($\pm$ 0.23) and 24.4 ($\pm$ 0.20) days

Table V. Duration of incubation of Franklin's Gull eggs.*

Incubation time in days	No. of eggs I	II	III	Total	Percent I	II	III	Total
21		1		1		3.0		1.3
22	3	1		4	7.9	3.0		5.0
23	4	3		7	10.5	9.1		8.8
24	12	11	2	25	31.6	33.3	22.2	31.2
25	10	12	6	28	26.3	36.4	66.7	35.0
26	4	5		9	10.5	15.2		11.2
27	4		1	5	10.5		11.1	6.2
28	1			1	2.7			1.3
Total	38	33	9	80	100.0	100.0	100.0	100.0
Mean	24.6	24.4	25.0	24.6				
S. E.	$\pm$0.23	$\pm$0.20	$\pm$0.27	$\pm$0.14				

*Data obtained in 1964 from Big Lake, Areas D and E, and in 1965 from Hay Lakes, Area SP.

respectively. However, the average length of incubation for a sample of nine eggs III is slightly longer, 25 ($\pm$ 0.27) days. One would expect the length of incubation to be shortest in egg III. The figure of 25 days was not statistically significant since the sample was so small. The average incubation period, for all three eggs, was 24.6 ($\pm$ 0.14) days.

Embryonic Growth

Ytreberg (1956) believes the greatest increase in weight in the embryo of Black-headed Gulls to be between 10 and 12 days of age. Drent (1967) and Paludan (1951) found that the percent of weight increase from day to day in Herring Gull embryos declines steadily throughout the embryonic period with the exception of a peak at about the 13 to 14th day of age. Romijn and Lokhorst (1951) discovered an increase in metabolic intensity in fowl at about the 10 to 13th day of embryonic development, which they felt was a result of the start of thyroid function. Romijn et al. (1952) obtained experimental results on embryonic fowl which would attribute this peak to a period of initial thyroid function.

In 1966 at Hay Lakes, the author collected 56 eggs from 23 clutches in order to determine embryonic growth. A peak in weight increase, similar to that found by Drent (1967) and Paludan (1951), occurred during the 13 to 14.5 day period in Franklin's Gull embryos. Table VI shows the weight and egg number of these embryos along with their related egg size. The embryos A, B and C correspond to eggs I, II and III respectively. The embryos varied in age from six to 24 days. There were 21 "A" embryos from eight to 24 days, 23 "B" embryos from seven to 23 days and 12 "C" embryos from six to 22 days. The larger eggs do not necessarily produce the heavier embryos. Note that in clutch number 395, egg I

measured 37.7 by 54.5 mm. and produced a 15-day embryo of 6.86 grams, while in clutch number 172, egg II was smaller (36.1 by 53.1 mm.), but produced a heavier 15-day-old embryo of 7.12 grams.

Table VI. Weight of 56 embryonic Franklin's Gulls taken from measured eggs I, II and III at different stages of development.*

Clutch No.	Age of eggs(d) I	II	III	Weight of embryos(g) A	B	C	Length - breadth of eggs(mm) I	II	III
391	8	7	6	0.59	0.46	0.22	50.3-34.5	49.7-35.8	50.0-34.6
363a	9	8	6	0.96	0.60	0.20	54.5-36.2	53.5-37.0	51.5-36.1
371	13	11	9	2.21	1.81	1.11	54.5-36.3	51.5-31.8	52.5-32.0
372	13	12		3.81	2.37		49.2-35.6	51.5-34.8	
375	11	9	7	1.58	0.98	0.49	49.3-34.6	49.7-35.0	49.5-34.1
168	12	10		1.68	1.05		50.0-37.6	49.8-36.3	
285	12	10		2.12	1.24		54.0-35.8	56.3-34.5	
364	10	8		1.22	0.50		52.7-35.8	54.9-35.2	
390	11	8		1.69	0.53		53.0-35.2	53.5-35.6	
172	14	15	12	4.59	7.12	2.63	52.6-35.2	53.1-36.1	52.5-35.0
395	15	14	11	6.86	5.34	2.69	54.5-37.7	56.5-37.9	53.4-36.5
283	14	13		4.32	3.57		51.1-36.9	49.9-36.4	
289	17	15	14	10.40	7.90	5.20	53.6-38.4	55.0-38.7	53.5-37.8
343	21	19	16	18.90	17.36	11.32	56.8-36.1	54.9-37.0	54.4-36.9
362	19	18	16	15.68	12.71	9.21	51.0-36.6	51.8-37.1	48.9-36.4
286	17	15		11.35	7.01		51.6-34.8	47.7-33.8	
363	16	16		10.22	10.78		52.6-35.1	50.4-35.2	
169	21	19		19.47	17.01		50.2-36.0	49.2-35.0	
80	23	21		26.12	25.15		51.5-37.2	51.9-37.8	
271		23	18		26.59	13.97		50.7-37.4	53.3-34.6
167	24	23	22	23.85	23.14	23.20		49.0-37.0	51.6-36.5
386	23	22	20	24.88	22.16	17.11	51.7-35.3	50.6-35.8	51.2-34.9
166		23			29.41			51.5-37.7	

*Data obtained in 1966 from Hay Lakes, areas P, Q, R and AN.

Other individual comparisons of egg size and similar-aged embryos show the reverse. Clutch number 375 egg I, which measured 34.6 by 49.3 mm. produced an 11-day embryo of 1.58 grams, while in clutch number 390, egg I was of a larger size, 35.2 by 53.0 mm., and produced a larger 11-day-old embryo of 1.69 grams. This variation in size is possibly a result of the

variation of attentiveness between individual pairs of gulls. Increased attentiveness may accelerate embryonic growth. Variations in embryo size may also be a consequence of genetic differences.

In Fig. 12 and Table VI, at a given embryonic age where all three embryos occur or where only two of the three occur, embryo C is, in most cases, largest, with embryo B of intermediate size and embryo A the smallest. This would support the hypothesis that the degree of attentiveness increases upon the completion of the laying of the entire clutch (Drent, 1964; Paludan, 1951; Vermeer, 1967; Ytreberg, 1956).

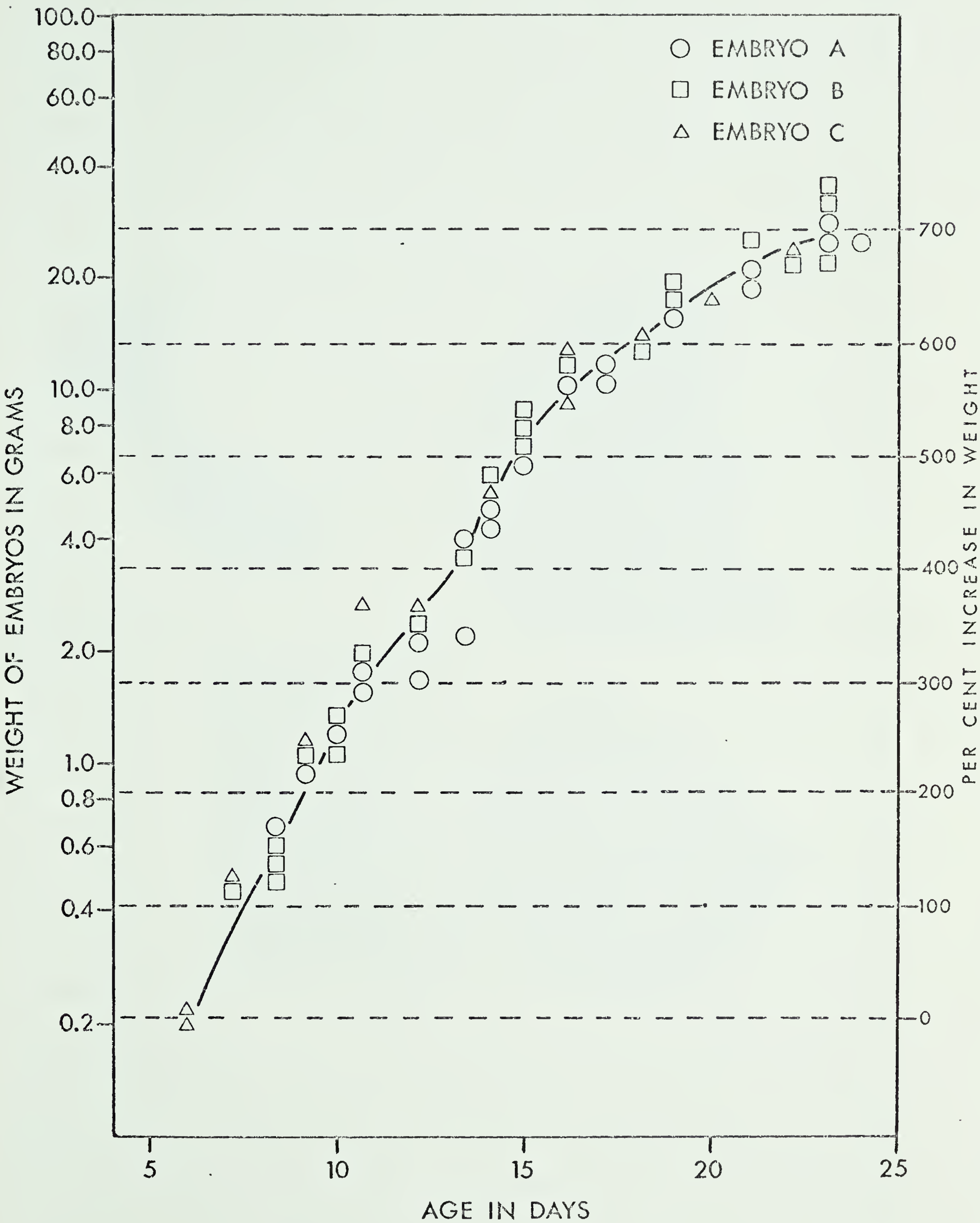
The rate of embryonic weight increase is quite uniform from 6 days to 10.5 days (Fig. 12): it doubles for every $1\frac{1}{2}$ days. From day 10.5 to 13 the weight doubles but requires $2\frac{1}{2}$ days. This decline is followed by a brief (13 to 14.5 day) return to the earlier rate of doubling every $1\frac{1}{2}$ days. The next period of doubling requires 3 days, from day 14.5 to 17.5. The final doubling of weight requires a $5\frac{1}{2}$ day period, from 17.5 to 23 days. Fig. 13, which shows photographs of five embryos at 6, 10, 15, 20 and 23 days of age illustrates these weight differences. There is a general trend, as with other birds, for the rate of weight increase in Franklin's Gull embryos to decline as the embryo increases in age.

Hatching

Hatching periods for other species of gulls were noted by Drent (1967) who obtained a mean hatching period of 20 days for initial clutches in Herring Gulls during a three-year study, and by Vermeer (1967) who obtained a hatching period of 24 days for California Gulls and 26 days for Ring-billed Gulls for initial clutches.

Jim Wolford (pers. comm.) found in 1964 in southern Alberta at

Fig. 12. Weight of 56 embryonic Franklin's Gulls collected at Hay Lakes, Alberta in 1966. Embryos A, B, and C correspond to eggs I, II, and III respectively. The weight in grams is plotted on a semi-logarithmic scale.



EMBRYO A
EMBRYO B
EMBRYO C
WEIGHT OF EMBRYOS IN GRAMS
100.0
80.0
60.0
40.0
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
PER CENT INCREASE IN WEIGHT
700
600
500
400
300
200
100
0
5
10
15
20
25
AGE IN DAYS

Fig. 13. Five embryonic Franklin's Gulls: 6, 10, 15, 20 and 23 days old.


6 DAYS
10 DAYS
15 DAYS
20 DAYS
23 DAYS

San Francisco Lake, that hatching in 21 clutches of Franklin's Gulls began on June 5 and terminated on June 15, a hatching period of 11 days. If these data are representative of the hatching period in southern Alberta, it would appear to begin sooner and to be shorter than that found in central Alberta. This seems congruent with the earlier and shorter laying period in southern Alberta and can probably be attributed to higher temperatures.

The frequencies and dates of hatching for Franklin's Gulls are shown in Fig. 10. Hatching began at Big Lake in 1964 on June 9 and extended to June 14, with the mean falling on June 12. This hatching period only lasted six days. The hatching information from Big Lake in 1964 is somewhat incomplete because of the small sample, a consequence of nest abandonment. Hatching at Hay Lakes in 1964 began on June 13 and terminated on June 24, with the mean on June 16. This hatching period lasted twelve days. The data from Hay Lakes in 1965 gives the most complete and accurate information for the hatching period. Hatching began on June 9 and terminated on June 25, resulting in a hatching period of 17 days with the mean on June 15. The average length of time from hatching of the first to hatching of the last egg on the study areas for Hay Lakes in 1964 and 1965 was 14.5 days. The data given represents initial clutches only, as hatching periods for replacement clutches were not obtained.

Eggs substituted by the author at Hay Lakes in 1966, during egg collection for known-age embryos, were accepted and hatched by recipient adult gulls.

From the time pipping begins in Franklin's Gulls, the chicks require an average of two days to emerge. Pipping activities ranged from a minimum of one day to a maximum of five days. The hatching process could

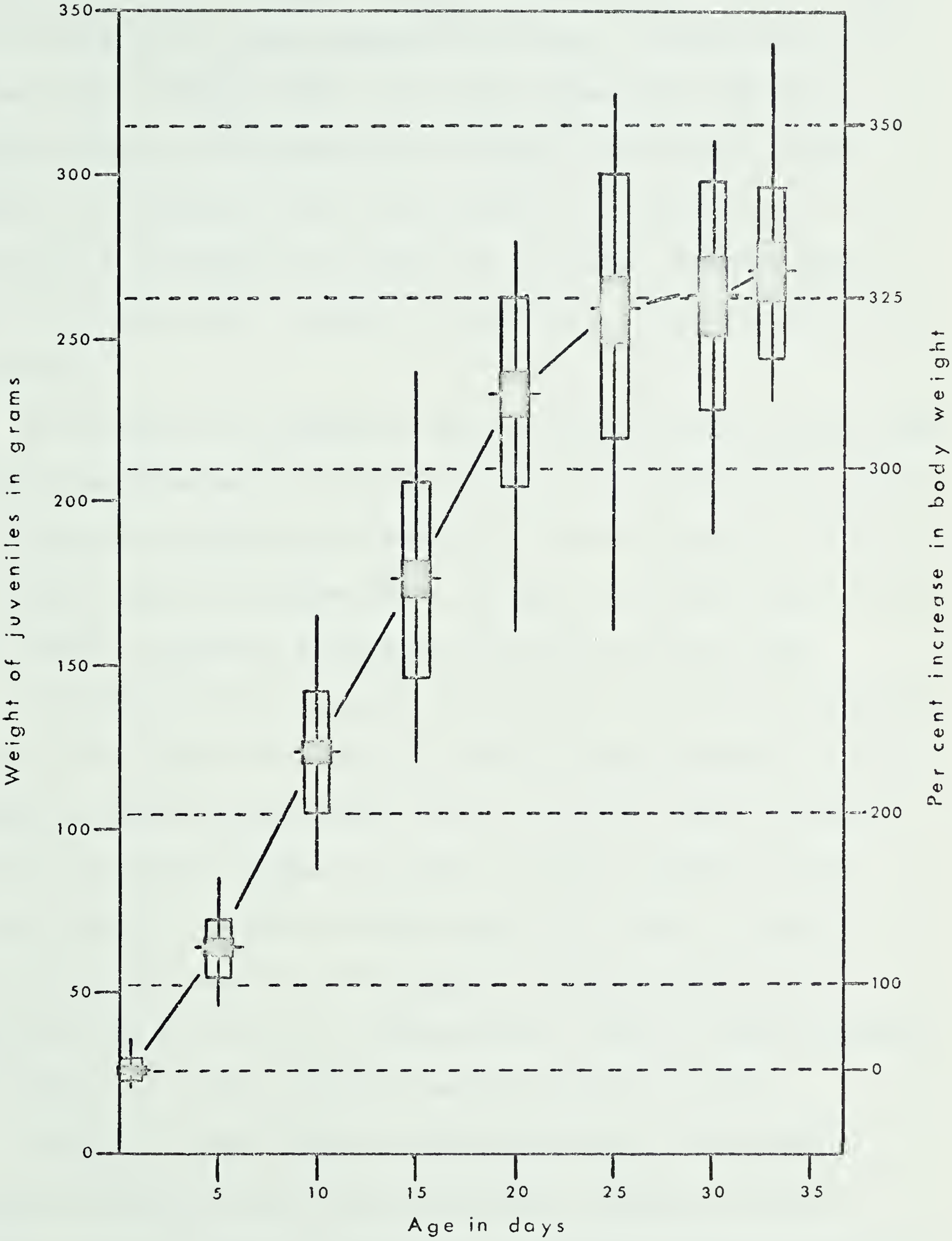
be accelerated by the time of day or the weather conditions present. Nest observations during these weather conditions revealed that if adverse weather occurred, such as rain, cold air temperature or extreme heat, pipping activities ceased. The hatching process probably stopped during the night. Absence of pipping activities during the night was not a direct observation, however morning inspections revealed very little progress in hatching since the previous late afternoon checks.

Growth of Young

Vermeer (1967) found that, on the average, chicks of California, Ringbilled and Glaucous-winged Gulls doubled their weight in $4\frac{1}{2}$ days, trebled it in 10 days and quadrupled it in 20 days. He found that the period of time required for a doubling in weight is progressively longer: 4 days, 6 days and 10 days. Vermeer (1967) showed that in broods of single chicks the young increase more rapidly in weight than chicks from broods of two or three.

From Fig. 14 it can be seen that the mean weight of a Franklin's Gull chick at hatching is 26 ($\pm$ 0.82) grams, with a range of 20 to 35 grams for a sample size of 79 chicks. At five days of age, the mean is 63 ($\pm$ 1.48) grams, with a range of 45 to 85 grams. The ten-day-old Franklin's Gull weighs, on the average, 137 ($\pm$ 3.25) grams, varying from 87 to 165 grams. At ten days of age, the chick has reached half its fledging weight. The 15-day and 20-day-old chicks average 176 ($\pm$ 5.75) and 233 ($\pm$ 6.40) grams respectively. The greatest range in weight, 160 to 325 grams, occurs at 25 days of age, with a mean weight of 259 ($\pm$ 9.87) grams. This is probably a result of differential

Fig. 14. Growth curve for 166 juvenal Franklin's Gulls from hatching to fledging in 1964 and 1965. Vertical lines indicate ranges, horizontal lines indicate means, open rectangles correspond to standard deviations, and solid rectangles indicate standard errors of the means.



350
300
250
200
150
100
50
0
Weight of juveniles in grams
5
10
15
20
25
30
35
Age in days
350
325
300
200
100
0
Per cent increase in body weight

feeding of various chicks by their parents and the fact that some chicks had begun to fledge. During the period between 25 and 30 days of age, growth levels off at a mean weight of 263 grams. In many cases this represents the fledging weight. For those chicks which required a slightly longer growth period before fledging, the weight increases slightly to an average of 270 ($\pm$ 9.11) grams at 33 days of age. The average age for fledging was 30 days and the average fledging weight was 263 ($\pm$ 11.52) grams. In Fig. 15 a one and a two-day-old chick are illustrated.

The necessity for studying growth and fledging weights of the young precluded determination of sex since this can be done only by dissection. Sex differences probably do not account for the wide ranges in weight at a particular age for the young birds. Weights of 100 adult males and 69 adult females revealed no significant differences between sexes.

In Franklin's Gulls the rate of weight gain of the young decreases with age. The author found that the period of time necessary for each doubling in weight increased from 4 days to $4\frac{1}{2}$ days, then to $9\frac{1}{2}$ days. The final 25 percent increase in weight occurred from day 18 to 28, a 10-day period. The rate of weight gain in the embryo is greater than that of the young bird. The embryos increased seven-fold in weight from day 6 to day 23, a 17-day period, while the young increased only $3\frac{1}{4}$-fold in a 30-day period, from day of hatch to day 30.

One-day-old downy chicks of Black-headed Gulls are capable of picking up worms and insects from the ground, disgorged by adults (Kirkman, 1937). They may also be seen searching for food on the first day of life.

During its first ten days of life, nearly all food that Franklin's

Fig. 15. One-day and two-day-old Franklin's Gulls on a nest, Hay Lakes, Alberta. June 11, 1965.

Gull chicks obtain is that provided by parents. Soft food, such as earthworms and insect larvae, are the primary food during this period. This was observed from regurgitations of the young, during the daily weighing periods. From this time on, the adults continue to feed the chicks, but to a lesser degree, as the chick increases its ability for self-feeding. After this period the young begin to eat more and more adult insects with hard exoskeletons. The success of the individual young at obtaining food probably varies and may be reflected in the increased divergence in weights as they age.

Reproductive Success

Fate of Eggs

Ytreberg (1956) describes an egg loss in Black-headed Gulls of 24.7 and 21.7 percent in 1952 and 1953 respectively. The major categories of egg loss for this species (given in percent of total egg loss) were: addled (25), disappeared (25), abandoned (16), pecked (16) and other minor causes such as weather and accidents totalling 18 percent. He noted that the bird which was responsible for most of the destruction of Black-headed Gulls' eggs was the Black-headed Gull itself. The fact that these birds steal eggs from members of their own species has been noted by Dunlop (1910), Kantak (1954), Kirkman (1937) and Witherby (1949). Tinbergen et al. (1962) mention that Black-headed Gulls, which may normally not attack an undamaged egg, will eat an egg once it has been broken.

Vermeer (1967) showed an egg loss in California Gulls of 25.8 percent in 1964 and 26.0 percent in 1965. His equivalent figures for Ring-billed Gulls were 13.8 and 84.0 percent. Drent (1967) described an egg loss of 34.3 percent in Herring Gulls. Other authors found egg

losses in Herring Gulls of 29 percent (Paynter, 1949), 30 percent (Paludan, 1951) and 36 percent (Harris, 1964). Drent (1967) found that egg loss in this species could be separated into several categories of causes: destroyed, 18.9 percent; addled, 13.7 percent; and died in hatching, 1.7 percent. He found in Herring Gulls that there was a preponderance of predation in the laying period, therefore the predation-risk was highest for the first eggs laid.

The fate of 418 unhatched eggs of Franklin's Gulls from areas of both maximal and minimal disturbance is shown in Table VII. The term "destroyed" refers to eggs which were found either remaining as only broken pieces of shells with the contents missing or intact with a hole pecked in the egg. The fact that some contents remained in some cases probably was due to the predator being chased away before it had accomplished its purpose. The majority of "destroyed" eggs had the contents missing. The primary causes of destruction were Franklin's Gulls and the only ones which the author had occasion to observe. On many occasions, clutches which were left unattended by both adults were destroyed by a neighboring Franklin's Gull. The eggs were eaten or had holes pecked in them. Egg destruction seems to be a typical behavior pattern in Franklin's Gulls. Areas undisturbed by the author also showed reduced clutch sizes and evidence of pecked and eaten eggs.

Under the category "disappeared" were those Franklin's Gull eggs which were present upon a nest inspection, but missing upon subsequent inspections.

"Abandoned" eggs were those which were warm to the touch during one nest inspection but felt cold upon subsequent inspections without visible evidence of damage. These eggs were eventually either destroyed or they

disappeared.

Some eggs were found floating in water adjacent to the nest, with no sign of destruction. These eggs were probably accidently pushed into the water by one of the parent gulls or by neighboring gulls. The latter was observed on three occasions by the author.

Table VII. Fate of unhatched Franklin's Gulls' eggs within the study areas.*

Cause of failure	1964 Egg laying	1964 Incubation	1965 Egg laying	1965 Incubation	1964-65 Egg laying	1964-65 Incubation	1964-65 Total(%)
1. Destroyed	108	34	72	62	180	96	276 (66)
2. Disappeared	3	2		3	3	5	8 (2)
3. Abandoned	1	24		86	1	110	111 (26)
4. Dropped into water	1	2			1	2	3 (1)
5. Died during hatching		2		18		20	20 (5)
Lost (Total)	113	64	72	169	185	233	418 (100)
Total eggs for areas	222		379		601		601

*Data obtained in 1964 from Big Lake, areas A, B, B', C, D, E and F, and in 1965 from Hay Lakes, areas J, U, L, M, G-N, SP, 500, 600, 700 and 800.

The eggs included in the "died during hatching" category were those in which the young had begun pipping but never completely emerged. These embryos were probably victims of adverse weather conditions, abandonment or a combination of both. The cold temperatures (38° F.) and heavy rainfall (1.54 inches) occurring in June, 1965 from the 22nd through the 28th coincided with the majority of failures of these embryos to complete the hatching process (Table VII and Table III). Evidence to support

this is from MacMullan and Eberhardt (1953) who demonstrate that pheasant embryos appear to be increasingly more vulnerable to chilling as incubation progresses. Chick embryos exposed to low temperatures after the fourth day of incubation showed a reduction in hatching success. However, most birds' eggs and embryos appear to be more susceptible to overheating than to chilling. Exposure of eggs to intense solar radiation will result in death of the embryos within a few hours (Drent, 1967). Incubation not only serves as a source of heat and protection from overheating, which are necessary for embryo development, but also reduces egg predation (Drent, 1967).

The "total lost" category represents the total of itemized causes of failure: one, two, three, four and five in Table VII.

The greatest loss of eggs for both 1964 and 1965 was from "destruction" which accounted for 66 percent of the total loss or 46 percent of the total number of eggs in the study areas. "Destruction" was higher during laying than incubation in 1964, but almost equal during laying and incubation in 1965. The data in 1965 were more complete. The second greatest loss was due to "abandonment" of eggs which accounted for 26 percent of the total loss or 18 percent of the total number of eggs in the study areas. "Abandonment" occurred primarily during incubation in both 1964 and 1965. The third largest egg loss was the death of the young during hatching which accounted for approximately five percent of the total egg loss and represents three percent of the total number of eggs in the study areas. Many more young "died during hatching" in 1965 than in the previous year. The adverse weather conditions between June 22 and 28 in 1965, as compared to the relatively uniform weather in 1964, probably account for this great difference (Table III). The total eggs lost by

"disappearance" was eight out of 418 eggs, and three out of 418 "dropped into the water."

The total egg loss as seen in Table VII was approximately 66 percent. This unusually high figure reflects the inclusion of data from areas of intense human disturbance. The effect of human disturbance on the fate of the eggs will be further discussed in the section entitled "Effects of Investigator." The normal egg loss appears to average 25 percent. Areas X, W and Z in 1964 and area SP in 1965 were the least disturbed areas.

Only one addled egg was discovered and this was found in a sample of 57 eggs collected for known-age embryos. The higher incidence of addled eggs in other species (Ytreberg, 1956) would suggest that other addled eggs probably occurred among the eggs which were destroyed, abandoned, disappeared or fell into the water. None of the eggs which were abandoned or fell into the water were broken open and examined. These eggs eventually were eaten or disappeared. Destroyed eggs with some contents present were examined and no other addled eggs were discovered. If one addled egg in 57 can be considered a true representation, it would appear that addled eggs in Franklin's Gulls occur with a very low frequency, as compared with Black-headed Gulls in Norway, in which addled eggs accounted for approximately 25 percent of the loss of all unhatched eggs in one study (Ytreberg, 1956).

Clutch Size

The following are mean clutch sizes found in other species of gulls: 2.38, Herring Gulls in Canada (Paynter, 1949); 2.75, Lesser Black-backed Gulls in Denmark (Paludan, 1951); 2.76, Herring Gulls in England (Harris,

1964); 2.77, Glaucous-winged Gulls in Canada (Drent et al., 1964); 2.77, California Gulls in Canada (Vermeer, 1967); 2.84, Ring-billed Gulls in U. S. A. (Johnston & Foster, 1954); 2.87, Ring-billed Gulls in Canada (Vermeer, 1967); 2.90, Black-headed Gulls in Norway (Ytreberg, 1956); 2.91, Herring Gulls in Denmark (Paludan, 1951). The mean clutch sizes for these six species of gulls range from 2.38 to 2.91, with an average of 2.77. Ytreberg (1960) found the clutches of Black-headed Gulls to consist of three eggs in 68 percent of the cases, two eggs in 26 percent and one egg in 6 percent.

Bent (1921) states that, as with the majority of gulls, the normal set of eggs for Franklin's Gulls is three, with two eggs sometimes constituting a full set. Jim Wolford (pers. comm.) in 1964 at San Francisco Lake in southern Alberta found 42 Franklin's Gulls' nests containing 103 eggs, an average clutch size of 2.45 ($\pm$ 0.09) eggs. The distribution of eggs per nest were as follows: 2 nests with one egg, 19 nests with two eggs and 21 nests with three eggs.

The areas from which the clutch sizes were obtained for Franklin's Gulls were not disturbed during the laying and most of the incubation periods. These areas were marked and the clutch size was recorded a few days prior to hatching. Thus the clutch size is a true representation of the natural condition, undisturbed by humans, at that stage of incubation.

The Franklin's Gull usually lays a clutch of three eggs (Fig. 9). Inspection of 68 female reproductive tracts showed that 90 percent of these birds had laid three eggs. The average clutch size as determined by nest inspection is less than three, which is probably due to destruction, accidents, or disturbance. The average clutch size for 39 nests in the least disturbed area was less than three (2.39).

The data for Table VIII were collected from the least disturbed study areas during the research period. Once again, the greatest percentage of the data were collected in 1965. It will be noted that the average clutch size was largest in 1966, smallest in 1965 and intermediate in 1964. The overall, average clutch size for the three summers was 2.16 ($\pm$ 0.04) eggs per clutch.

Table VIII. Clutch sizes recorded in Franklin's Gulls.*

Clutch size	No. of clutches 1964	1965	1966	Total	Percent 1964	1965	1966	Total
1	15	13	1	29	25.9	11.1	3.0	13.9
2	19	80	18	117	32.7	68.4	54.6	56.3
3	24	24	14	62	41.4	20.5	42.4	29.8
Total	58	117	33	208	100.0	100.0	100.0	100.0
Mean	2.16	2.09	2.39	2.16				
S. E.	$\pm$0.11	$\pm$0.05	$\pm$0.10	$\pm$0.04				

*All data obtained from Hay Lakes: areas X, W and Z in 1964, areas SP, 500, 600, 700 and 800 in 1965, and areas P, Q, R and AN in 1966.

The reproductive success of Franklin's Gulls at Hay Lakes was higher in 1964 than in 1965. The values for reproductive success in 1964 and 1965 are presented in Table IX. Only initial clutches have been utilized as the data from replacement clutches were insufficient. Only three known replacement clutches were positively identified upon inspection of 68 female reproductive tracts from females from another area of the colony.

The overall clutch size for 1964, 1965 and 1966 for the least

disturbed areas was 2.16. From Table IX it can be seen that clutch size was higher in 1964 with a mean of 2.2 and a range of 2.1 to 2.5. The clutch size in 1965 showed a mean of 2.1 eggs. It would appear that the clutch size of Franklin's Gulls is lower than that of other species of gulls.

Table IX. A comparison among laying, hatching and fledging success of Franklin's Gulls.

Date	Area	No. of Nests	Ave. Clutch Size	Hatching No. Per Clutch	Hatching Per Cent	Fledging No. Per Clutch	Fledging Per Cent
1964	X	14	2.5	1.86	74.2	0.50	26.9
	W	36	2.2	1.72	78.2	0.25	14.5
	Z	11	2.1	1.46	69.6	0.45	30.8
Average			2.2	1.69	75.7	0.34	20.4
1965	700	17	2.1	1.16	55.3	0.06	5.2
	800	14	2.1	1.40	66.7	0.29	20.7
Average			2.1	1.27	60.4	0.16	12.2

Hatching Success

The hatching success in Black-headed Gulls in Norway in 1952 and 1953 was 75.3 percent and 78.3 percent respectively (Ytreberg, 1956). Paludan (1951) found for Herring Gulls a hatching success of only 55.5 percent in 1944, compared to 1943 in which it was in excess of 70 percent. This lowered success was the consequence of a heavy gale which washed away many nests. Vermeer (1967) at Miquelon Lake, Alberta, showed a hatching success of 74.2 percent in 1964 and 74 percent in 1965 for California Gulls. Results for Ring-billed Gulls were 86.2 and 16 percent respectively.

The hatching success of Franklin's Gulls was greater in 1964 than in 1965 as a consequence of extreme weather conditions in 1965. The mean for 1964 was 75.7 percent or 1.69 young per clutch, with a range of 69.6 to 78.2 percent (Table IX). In 1965, the mean was 60.4 percent, or 1.27 young per clutch, with a variation of 55.3 to 66.7 percent.

Fledging Success

The major cause of death in young gulls is pecking by adults. Kirkman (1937) speaking of Black-headed Gulls, states,

> "I have seen a chick pecked by seven adults in succession before it got back to its nest, and another driven thirty to forty yards out of its course and back again by merciless beaks. The usual end of such incidents is death."

The pecking by adult Black-headed Gulls of strange chicks which have wandered onto their territory appears to be a major cause of death in the young. Vermeer (1963) found that the primary cause of chick mortality in Glaucous-winged Gulls on Mandarte Island was the pecking to death of chicks by adults when they wandered onto another gull's territory. This was also a major cause of chick mortality for Ring-billed and California Gulls in 1964 at Miquelon Lake, Alberta (Vermeer, 1967). This was also the primary cause of chick mortality in other gull studies: Herring Gulls in Denmark (Paludan, 1951), Herring Gulls in New Brunswick, Canada (Paynter, 1949), and in Ring-billed Gulls in Michigan, U. S. A. (Emlen, 1956).

Vermeer (1967) found that gull chicks are very susceptible to death if exposed to rainstorms. He cites an example of seven California Gull chicks dying in 1964 as a result of disturbance prior to a rainstorm. The young became wet and chilled. In June, 1965, rainfall which persisted over three successive days resulted in the death of many California and

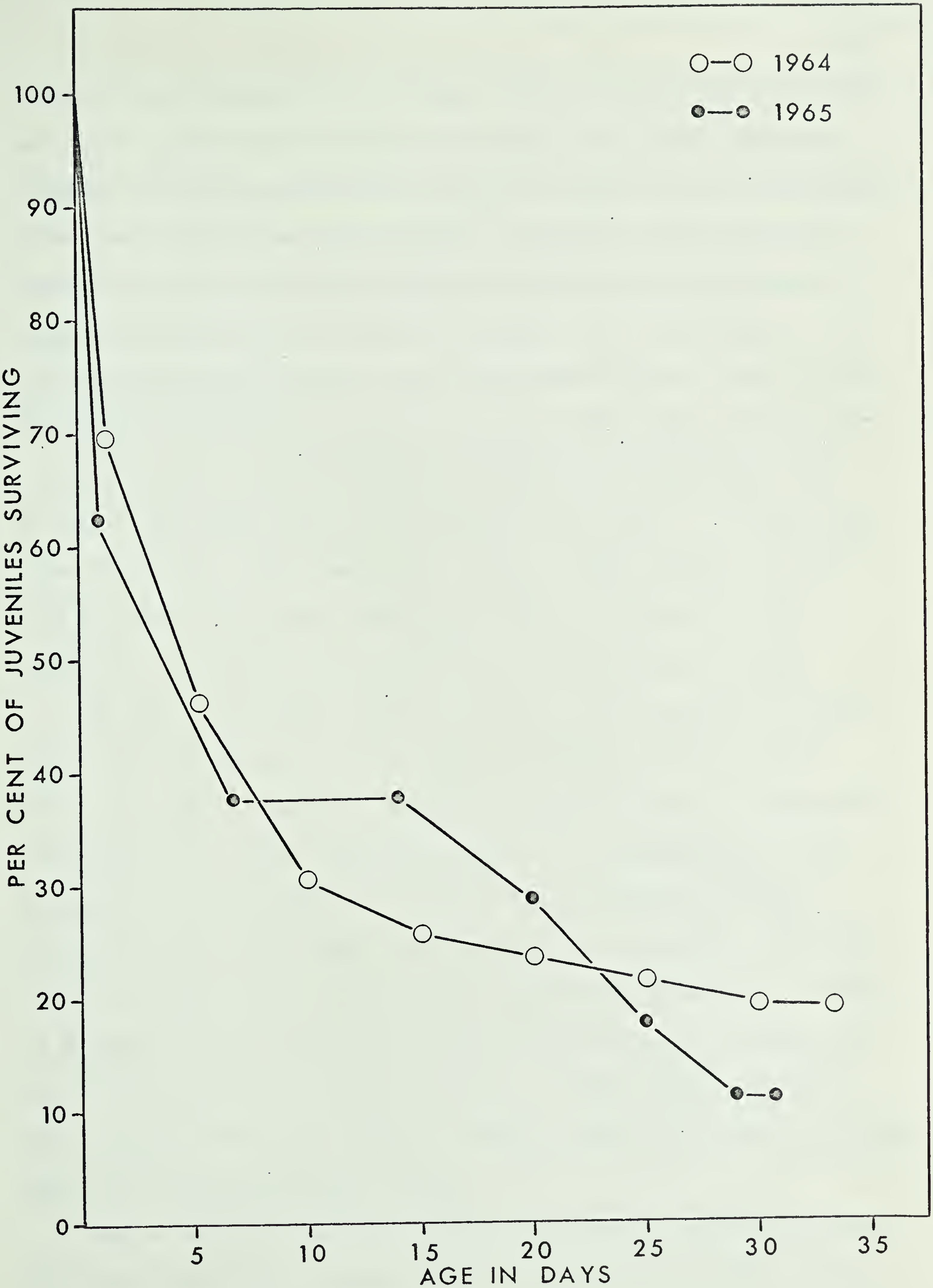
Ring-billed Gulls. Paludan (1951) noted that some Herring Gull chicks had been killed by rain or brilliant sunshine.

Paludan (1951) states that by eight days of age only 30 percent of Herring Gull chicks had survived, and no more than 20 percent of the chicks on the experimental area reached the age where they could leave the colony. Vermeer (1967) obtained a fledging success in 1964 of 48.8 percent for California Gulls and 39.9 percent for Ring-billed Gulls; in 1965 not one chick fledged.

The fledging successes in 1964 for areas X, W and Z respectively, as seen in Table IX, were 26.9, 14.5 and 30.5 percent or 0.5, 0.25 and 0.45 young per clutch. The mean fledging success for 1964 was 20.4 percent or 0.34 young per clutch. The 1964 figures contain more data and therefore appear to be a more accurate representation. The mean fledging success in 1965 resulted in 12.2 percent or 0.16 young per clutch. The study areas 700 and 800 produced respectively 5.2 and 20.7 percent or 0.06 and 0.29 young per clutch. This low reproductive success in 1965 was due to a continued disturbance and extreme weather conditions, such as heavy rainfall (1.54 inches) and cold temperatures (38° F.) between June 22 and June 28, 1965 (Table III). The increase in human disturbance brought about an increase in nest abandonment and/or destruction. The extreme rainfall dismantled nests, resulting in the loss of eggs and the death of young from exposure.

Fig. 16 depicts the survival of 166 young Franklin's Gulls from hatching to fledging in 1964 and 1965. Mortality was heaviest during the first two days, 30 percent in 1964 and 38 percent in 1965. By the time the young were five days old, 55 percent of them in 1964 and 63 percent in 1965 were dead. In 1965, mortality of the young leveled

Fig. 16. Survival to fledging of 166 juvenal Franklin's Gulls in 1964 and 1965.



1964
1965
100
90
80
70
60
50
40
30
20
10
0
PER CENT OF JUVENILES SURVIVING
5
10
15
20
25
30
35
AGE IN DAYS

off for the age group of six to 14 days. Then at 14 days of age in 1965, mortality increased quite rapidly to fledging. The 14-day stage when compared with the hatching peak of June 14 for 1965 in Fig. 10 corresponds almost perfectly to the extreme rainfall, which fell between June 26 and June 28. Thus the sudden increase of mortality at 14 days might be explained by these adverse weather conditions. The continuation of this rate of mortality may indicate the longer-lasting effects of poor weather conditions. The survival rate of the young in 1964 ended a rapid decline at ten days of age and then decreased slightly to fledging (Fig. 16). In 1964, the fledging age or first flight varied from 23 to 33 days with a mean of 30 days. The fledging age ranged in 1965 from 24 to 31 days with an average of 28 days. The young in 1964, as compared to 1965, appeared to require about two days longer on the average to fledge.

The major recognizable causes of death in the young were pecking by adult gulls and exposure to heavy rains. Pecking by adults occurred when young birds attempted to enter the nesting territory of a neighboring Franklin's Gull. These territories appear to be maintained until the fledging of the young birds. The parent gulls pecked the intruding young on the head until either the young left or were killed. The fencing of the young within the study areas undoubtedly limited their freedom of movement with the result that many young intruded upon a neighboring gull's territory and were pecked to death. To what degree the fencing increased the mortality is unknown. However, many young outside the fenced areas were also found pecked to death.

Many other young Franklin's Gulls were found dead inside and outside the fenced areas with no external signs as to the cause of death. The young that died within the fenced areas showed a gradual weight loss over

a period of several days, just prior to death. It is possible death was an indirect result of pesticide residues. The young had either been abandoned by their parents or were not fed, in which case they starved. Under these conditions, the sub-lethal levels of pesticide residues may have become lethal. (See "Pesticide Residues" section for further discussion.)

Survival of a Population

Paludan (1951) states that in an experimental study area approximately 2.5 chicks hatched per pair of Herring Gulls and slightly less than 2 per pair of Lesser Black-backed Gulls, equivalent fledging rates were 20 and 5 percent respectively. He felt that these figures were probably too low for the entire gullery. Paludan (1951) arrived at a mortality rate of approximately 15 percent for sexually mature birds within a population by statistical calculations from Danish banding data. He concluded that each population must produce $\frac{1}{2}$ to 1 chick per pair of adults in order to maintain itself. Marshall's (1947) mortality rate for sexually mature birds in an American Herring Gull population was approximately 29 percent. Paludan (1951) felt that in order for an American Herring Gull population to survive it must have a higher fledging rate than the Danish population.

It would appear that the fledging success of Franklin's Gulls in 1964 at Hay Lakes for study area X (Table IX) would meet Paludan's (1951) minimum of 0.5 young per clutch required to maintain a population. The other study areas as shown in Table IX are below this minimum. The author attempted to minimize the effect of human disturbance on the reproductive success of these gulls. The fledging rate was probably

higher for the population as a whole than for the areas studied.

If the longevity and average life span of Franklin's Gulls are similar to that of Black-headed Gulls, which are known to live as long as $18\frac{1}{2}$ years (Kate, 1948), then these parameters would mitigate the effect of the low reproductive rate and would probably maintain a population.

Effects of Investigator

Effect on Productivity

Very few investigators working on natural bird populations have mentioned the effects that they themselves have on the species and consequently on the data derived from it. Most choose to disregard these factors or attempt to delete the data affected by human disturbance.

Drent (1967), while describing reproductive success in Herring Gulls, states that the figures represent the "undisturbed nests." This would indicate that he felt that some nests had been disturbed to an extent that they would have affected his data.

Vermeer (1967) mentions that the time of later clutch commencement in Ring-billed Gulls may have been a consequence of human disturbance, i.e. his working on the island where the gulls nested. In 1964, the year when an observation tower was constructed and considerable movements took place around the tower by Vermeer (1967), 56 percent of 470 nests of California Gulls and 16 percent of 215 Ring-billed Gull nests were abandoned. The majority of California Gulls were nesting in close proximity to the observation tower and the Ring-billed Gulls were located much farther away. In 1964, Vermeer found a fledging rate of 48.8 and 39.9 percent in California and Ring-billed Gulls respectively. In 1965, not a single chick of either species fledged. Vermeer (1967) states that "the

complete failure to produce fledglings in 1965 at Miquelon Lake is not completely understood." He further states that this appeared to be a local phenomenon as the fledging success for these species appeared normal at a location 22 miles away. He hypothesized that parental neglect is responsible for the poor reproductive success in 1965 as compared to 1964, but does not explain the reason for this increase in negligence. Vermeer's data (1967) on nest numbers shows a drastic reduction of gull nests from 1964 to 1965. The Island "A" location showed a reduction from 470 to 87 California Gulls' nests and a reduction from 315 to 58 Ring-billed Gulls' nests from 1964 to 1965. Island "B" colonies showed a similar reduction: California Gulls dropping from 300 in 1964 to 44 in 1965 and Ring-billed Gulls from 1200 in 1964 to 378 in 1965. These figures represent respective decreases in the number of nests from 1964 to 1965 of 85.3, 81.6, 81.5 and 68.5 percent.

Wolford (1966), studying Black-crowned Night Herons in southern Alberta, found a reduction in the number of nests and reproductive success over a study of two breeding seasons. In addition to a reduction of Night Herons' initial nests from 71 in 1964 to 55 in 1965, a new nesting location was established by the birds in 1965. The hatching success decreased from 33 percent in 1964 to 13 percent in 1965 in initial clutches. The fledging success likewise dropped from 51 percent in 1964 to 10 percent in 1965.

The results of these studies (Vermeer, 1967; Wolford, 1966) suggest that the investigator's presence may be disturbing to the birds.

The effects of my presence in the study areas are reflected in laying, hatching and fledging success.

Table X is divided into two sub-tables, one for 1964 at the top and one for 1965 at the bottom. Each sub-table is further sub-divided into two parts: Human disturbance, which includes the marking date, final date the nest was checked, the number of daily nest checks, and the time required to fence off the areas where the young were studied. The second division shows the results of the disturbance as it is reflected in egg loss, hatching success, fledging success, clutch size or number of eggs laid. Fencing was required only on the plots in which hatching was studied.

Given the average density of nests, the approximate size of the various study plots may be estimated by the number of nests they contain. Since it took one minute, on the average, to check a nest, the larger the number of nests in an area, the more time required to check that area.

At Big Lake in 1964, the laying peak was May 18 and the nest-marking dates were May 13 (areas A, B and C), May 15 (area D), May 16 (area E), May 17 (area F) and May 18 (area B'). The hatching peak at Big Lake for areas D and E was June 12; hatching successes were 12.2 and 11.0 percent respectively. Hatching peaks were not obtained for the other areas at Big Lake, since the nests were only followed through the laying period to May 31. The reason these areas were deleted from the study after this date was because all nests in these areas were abandoned. Therefore, egg loss for areas A, B, B', C and F should be considered to be 100 percent.

At Hay Lakes in 1964, areas X, W and Z were marked June 14, two days before the hatching peak, June 16. The time required to fence these areas was relatively short, reducing disturbance. They showed a very high hatching success of 74.2, 78.2 and 69.6 percent, and a very low egg loss of 25.8, 21.8 and 30.4 percent. The fledging success for these

Table X. Influence of investigator disturbance on reproductive success in Franklin's Gulls.*

Human Disturbance	Areas - 1964 A[b]	B[b]	C[b]	D[c]	E[c]	F[b]	B'[b]	X[d]	W[d]	Z[d]
Marking date	My13	My13	My13	My15	My16	My17	My19	Je14	Je14	Je14
Final check	My31[e]	My31[e]	My31[e]	Je14	Je14	My31[e]	My31[e]	Jy20	Jy20	Jy20
No. Daily checks	1	1	1	1	1	1	1	1	1	1
Fencing time (hr.)[d]								2	3	2
Results										
Egg loss(%)	47.4	75.0	33.3	88.8	89.0	81.5	50.0	25.7	21.8	30.4
Hatch. success(%)				12.2	11.0			74.2	78.2	69.6
Fledg. success[a]								0.5	0.25	0.45
Ave. clutch size								2.5	2.2	2.1
No. of nests	71	50	82	30	81	26	5	14	36	11
No. eggs laid	19	8	12	41	109	27	6	35	78	23

*Laying peak in 1964 was May 18; hatching peak in 1964 was June 12 for Big Lake, Areas D and E and June 16 for Hay Lakes, Areas X, W and Z.

Human Disturbance	Areas - 1965 J[b]	L[b]	M[b]	U[b]	SP[c]	G-N[b]	500[d+]	600[d+]	700[d+]	800[d+]
Marking date	My12	My12	My12	My12	My21	My26	Je10	Je10	Je20	Je20
Final check	Je8[e]	Je8[e]	Je8[e]	Je8[e]	Je23	Je8[e]	Jy11	Jy11	Jy19	Jy21
No. Daily checks	3	3	3	3	1	3	1	1	1	1
Fencing time (hr.)[d]							6	6	2	2
Results										
Egg loss(%)	95.9	83.3	78.1	83.3	23.3	25.0	93.8	95.8	44.7	33.3
Hatch. success(%)					76.7		6.2	4.2	55.3	66.7
Fledg. success[a]							0	0	0.06	0.29
Ave. clutch size					2.1		2.4	2.1	2.0	2.0
No. of nests	146	75	64	32	39	36	22	23	17	14
No. eggs laid	49	12	41	12	90	12	48	48	38	30

*Laying peak in 1965 was May 22; hatching peak in 1965 was June 15.
[a]Number of young per clutch. [b]Areas marked for laying period only. [c]Areas marked for laying, incubation and hatching periods. [d]Areas marked for hatching period and growth to fledging. [e]Areas were no longer checked as nests appeared abandoned. +Heavy rains between June 26-28 caused the lake level to rise six inches.

three areas was 0.50, 0.25 and 0.45 young per clutch.

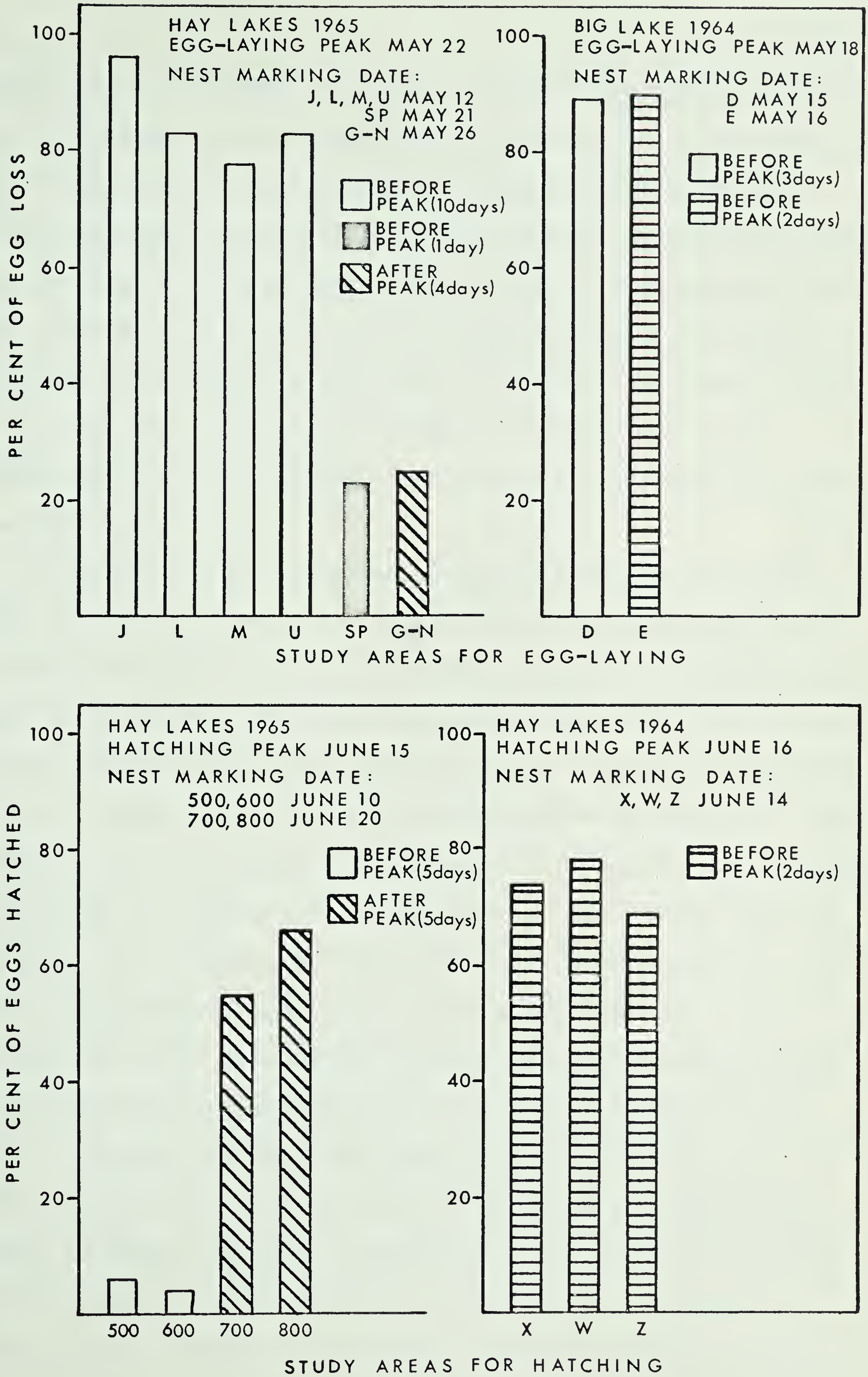
The data for the laying period in 1965 at Hay Lakes show a more complete picture. Areas J, L, M, U and G-N were checked through June 8, which included the entire laying period and three-fourths of the incubation period. The laying peak was May 22. In areas J, L, M and U, marked May 12, ten days in advance of the laying peak, the egg loss was extremely high: 95.9, 83.3, 78.1 and 83.3 percent. Also noteworthy is the low number of eggs per nest that were laid: 49 eggs for 146 nests, 12 eggs for 15 nests, 41 eggs for 64 nests and 12 eggs for 32 nests. The average clutch size in the least disturbed areas is 2.16. Area SP, which was marked May 21, just one day before the laying peak, had only a 23.3 percent egg loss. Area G-N, which was marked May 26, four days after the peak, only lost 25.0 percent of the eggs.

Areas 500 and 600 in 1965 at Hay Lakes were marked June 10, five days before the hatching peak of June 15, and the egg loss was very high: 93.8 and 95.8 percent, with a hatching success of 6.2 and 4.2 percent. These areas the author fenced alone and this took about six hours per area. Areas 700 and 800 were fenced with assistance June 20, five days after the hatching peak, and, with assistance, required only two hours per area for fencing (as contrasted with six hours for areas 500 and 600). The hatching results for these areas were 44.7 and 33.3 percent egg loss and 55.3 and 66.7 percent hatching success; a fledging success of 0.06 for area 700 and 0.20 young per clutch for area 800. I am unable to explain why area 700 had such a high mortality rate as compared to area 800, however, this area (700) is an exception to the typical pattern and occurred in only one study area out of twenty (Table X).

Perhaps the low hatching and fledging success in areas 500, 600, 700 and 800 were due to the very heavy rains between June 26 and 28 (Table III), which resulted in a rise in the water level of more than six inches. Despite the fact that Franklin's Gulls build floating nests, the rapid rise in water level dismantled many of the nests and the eggs fell into the water. Many young, which were ten to fourteen days old, died, probably as the result of exposure to these adverse weather conditions.

Fig. 17 emphasizes the major human disturbance. This graph shows the egg loss and hatching success as related to the nest-marking date. Areas J, L, M and U (Fig. 17) were marked ten days before the laying peak, and have a very high egg loss. Areas D and E, marked three days and two days, respectively, before the peak, also had a high egg loss. Area SP, which was marked one day before the peak and G-N, marked four days after the peak, had a very low egg loss. Areas D and E, which both had a high egg loss, differ from area SP, which had a low egg loss, by only two days and one day respectively. It may be that this is a very critical period and a single day is quite important. The reason for this large discrepancy with a difference in marking time of only one day may also be due to the fact that areas D and E were located at Big Lake which appears to have a transient population of gulls. The gulls appeared to nest at Big Lake one year, i.e. in 1964, but due to the high water, they did not nest there in 1965 and 1966. The gull colony there appears to be relatively new and unstable. In contrast, area SP was located at Hay Lakes, within a well established colony of two thousand pairs which remained stable throughout 1964, 1965 and 1966. The gulls at Hay Lakes would have more attachment to the nesting area in which their species have nested since 1931 (Farley, 1932) than would those gulls at Big Lake. This would contribute to a

Fig. 17. Hatching success in Franklin's Gulls correlated with the nest-marking date.



HAY LAKES 1965
EGG-LAYING PEAK MAY 22
NEST MARKING DATE:
J, L, M, U MAY 12
SP MAY 21
G-N MAY 26
BEFORE PEAK (10days)
BEFORE PEAK (1day)
AFTER PEAK (4days)
BIG LAKE 1964
EGG-LAYING PEAK MAY 18
NEST MARKING DATE:
D MAY 15
E MAY 16
BEFORE PEAK (3days)
BEFORE PEAK (2days)
PER CENT OF EGG LOSS
100
80
60
40
20
J
L
M
U
SP
G-N
D
E
STUDY AREAS FOR EGG-LAYING
HAY LAKES 1965
HATCHING PEAK JUNE 15
NEST MARKING DATE:
500, 600 JUNE 10
700, 800 JUNE 20
BEFORE PEAK (5days)
AFTER PEAK (5days)
HAY LAKES 1964
HATCHING PEAK JUNE 16
NEST MARKING DATE:
X, W, Z JUNE 14
BEFORE PEAK (2days)
PER CENT OF EGGS HATCHED
500
600
700
800
X
W
Z
STUDY AREAS FOR HATCHING

greater ease of abandonment at Big Lake. Another factor which may account for the large egg loss with a difference in marking of only one or two days was the method of nest-marking and checking in 1964 at Big Lake. At Big Lake stakes were more visible since the upper six inches were orange. This possibly increased predation. Also, during the same year, the stakes were numbered on the study area and data were recorded in a notebook, increasing the time spent on each area. In contrast, the stakes in 1965 at Hay Lakes were unpainted, pre-numbered, pre-distributed and data recorded by symbols on hole-punched nest record cards, resulting in less time spent per nest check.

A decrease in human disturbance results in a decrease in abandonment, as reflected generally in improved results and techniques in 1965 over 1964. The most critical human influence appears to be the nest-marking date. As the marking date of nests approaches the laying peak, the laying success (determined from clutch size) increases. Similarly, the hatching success increases as the marking date approaches the hatching peak. The marking of the nests several days in advance of the peak is more detrimental than marking of the nests several days after the peak. Nests marked one day before the laying peak had a hatching success of 75 percent (area SP) while those marked ten days in advance had only a 20 percent success (areas J, L, M, U). Areas marked five days before the hatching peak had a 5 percent hatching success (areas 500 and 600) and marked five days after the hatching peak had a 60 percent success (700 and 800). The marking of nests one to two days prior to the laying or hatching peaks appears to produce the highest reproductive success (areas X, W, Z, SP). Ease of abandonment and disturbance are also related to attachment to nests and areas. Attachment was shown to be weak to the Big Lake area.

The longer the time a bird spends on a nest and/or eggs, the greater the attachment. The fact that gulls would have less attachment to a nest before eggs had been laid probably influenced the high rates of abandonment. Low rates of abandonment, especially during hatching, would reflect high rates of attachment. The rapidity with which the gulls are able to construct a nest also contributes to the ease of abandonment during the laying period. It was not uncommon to find a nest completely built and one egg laid in a 24-hour period.

Effects of Continual Observation

On May 22, 1966 at Hay Lakes, a four by four by four feet, green canvas observation blind was erected upon a wooden platform, six inches above the water level. The site chosen was a previously undisturbed nesting area. The observation area had an average water depth of one foot and had a uniform vegetative cover of emergent *Scirpus acutus*. Observations of adult incubating behavior were made from 9:00 a.m. to 6:00 p.m. daily for a period of twelve days. Laying, for the most part, was complete and incubation was underway. On May 23, thirteen nests were marked with numbered, wooden stakes. The nests varied in distance from 18 feet to 73 feet from the blind. Because of the density of nests, which was approximately nine feet square per nest, and the height and density of the vegetative cover, more nests were not readily visible from one point. Fig. 18 shows the locations of the individual nests and their relationship to the blind. Table XI gives the distances of the nests from the blind. Eight of the thirteen nests had an adult gull from each pair color-marked on the breast with paint. The author was unable to mark any birds from the remaining pairs.

Fig. 18. Relationships of location of nests to blind and to one another within the observation area at Hay Lakes, Alberta.

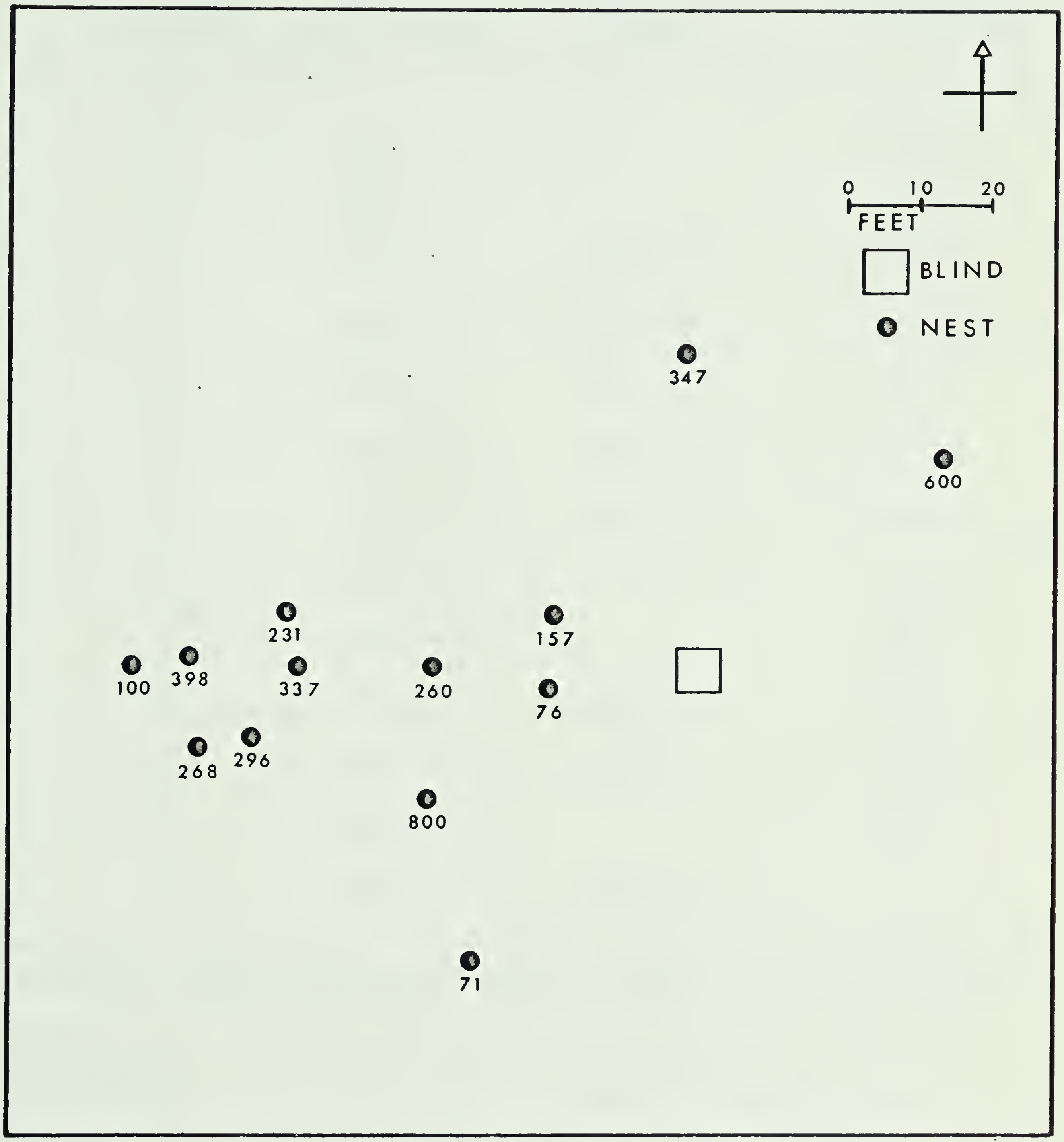

0 10 20
FEET
BLIND
NEST
347
600
231
157
100
398
337
260
76
268
296
800
71

Table XI. Nest abandonment of Franklin's Gulls as a result of observation of nests and color-marking adult birds.*

Nest	Distance in feet of nest from blind	Date of nest marking	Date of adult color-marking	Date nest was abandoned
76	18	May 23		May 23
157	21	May 23		May 25
260†	33	May 23	May 24	May 27
800†	40	May 26	May 26	May 28
347†	42	May 24	May 24	May 27
600†	43	May 25	May 25	May 29
71†	51	May 26	May 26	May 27
337	51	May 23		May 27
231	55	May 23		May 27
296†	60	May 23	May 25	May 27
398†	66	May 24	May 24	May 26
268	67	May 23		May 27
100†	73	May 24	May 24	#

*The area was under observation daily from May 22 to June 2, 1966.

†Only one adult gull from each of the nest pairs was trapped and color-marked.

#This pair of gulls did not abandon their nest.

It can be seen from Table XI that nests number 76 and 157 which were the closest nests to the blind, only 18 feet and 21 feet respectively, were the first nests marked on May 23 and also the first set of nests abandoned, on May 25. Nest number 398, which was marked on May 24, was abandoned next (May 26). Although nest 398 was 66 feet from the

blind, its proximity to nest number 100 resulted in its early abandonment. The pair of gulls at nest 100 were the most aggressive in the observation area. After marking nests 100 and 398 and one adult from each nest on May 24, the gulls were disturbed and the golden-colored gull from nest 100 destroyed an egg in nest 398. Several raging battles occurred between the gulls of these nests during the observation period on May 24 and 25. The owners of nest 100 attempted to drive off those of nest 398. As a result, the latter nest was abandoned on May 26. The marking of both these nests appeared to initiate the hostility between the adult gulls who had constructed them.

Nests 260, 347, 71, 337, 231, 296 and 268 were all abandoned on May 27. All were marked on May 23, with the exception of nest 71, which was marked on May 27. Nests 260, 337, 231, 296 and 268 were located quite close to one another and nests 347 and 71 were rather isolated.

Nests 800 and 600 were abandoned on May 28 and 29 respectively. Nest 800 was marked on May 26 and nest 600 on May 25. Both were somewhat isolated from the other nests.

Nest 100 which was farthest from the observation blind belonged to the most aggressive pair of gulls in the observation area. It was not abandoned.

Thus it appears that nests located closest to the blind may be the first to be abandoned and the ones farthest away may be abandoned last, if at all. Proximity of nests to one another and to other pairs of gulls, as in the case of nest 100, also influences the sequence and occurrence of nest abandonment (Table XI and Fig. 18).

The effect of investigator disturbance is most evident in the rate of abandonment of nests, which was found to be as high as 92 percent.

It also affected the sequence of abandonment, with the nearest gulls abandoning first. Observation leads to an increase of aggressive behavior between gulls nesting in close proximity.

Female Reproductive Cycle

Changes in Size of the Largest Preovulatory Follicle

Avian investigators (Bullough, 1942; Johnston, 1956; Marshall, 1949; Stieve, 1919) have shown that adult female birds annually undergo a cyclic change in the ovary and associated structures, such as the oviduct, which is generally parallel to similar cyclic change in the male. Paludan (1951) found four follicles 36, 32, 27 and 19 mm. in diameter in an adult Herring Gull (a larger bird than Franklin's Gulls) only two days before laying its first egg. He found no collapsed follicles macroscopically visible on the surface of ovaries of Herring Gulls nine days after the last eggs were laid. He found in both this species and the Lesser Black-backed Gull that the interval between the loss of a clutch and the beginning of replacement laying was 11 to 12 days. He states further that this interval remains constant whether the clutch is lost at the termination of initial laying or at a later date. Johnston (1956) found that the maximum size of adult winter follicles in California Gulls averaged 1.5 to 2.0 mm. in diameter. He also found that follicular development commences in mid-February, with the follicles enlarging abruptly to a mean of approximately 8 mm. by the end of April. He observed that ovulated follicles were resorbed rather rapidly in California Gulls, in most cases within a week.

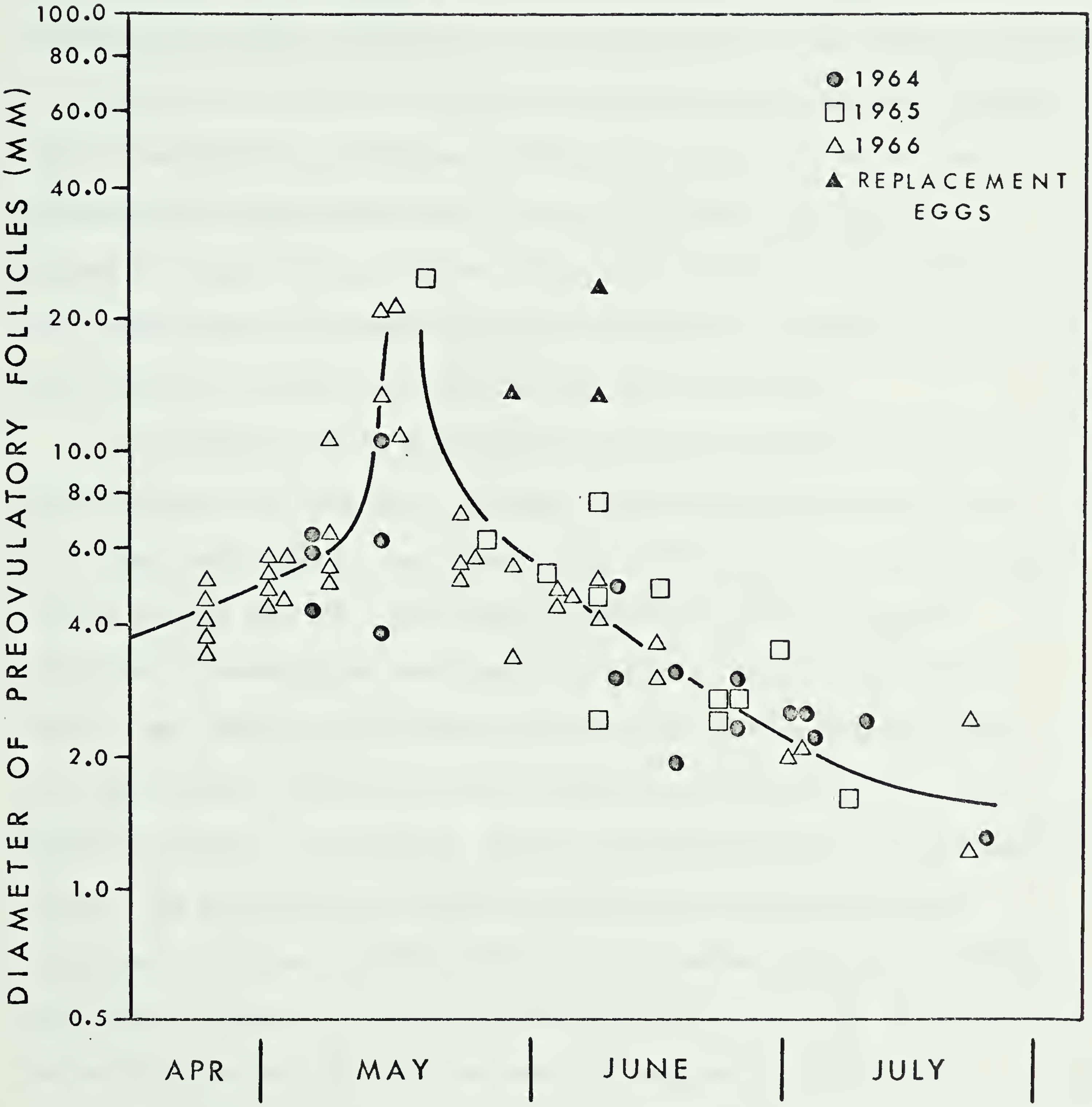
Stieve (1919) reports that follicular involution, which was observed microscopically in the Jackdaw (Corvus monedula), begins after the second egg is laid. However, he states that some follicles showed no signs of

involution after a four-week period of incubation by some females. Bullough (1942) found by microscopic examination of Starling (*Sturnus vulgaris*) ovaries what he calls corpora lutea persisting two months after incubation. Lewin (1963) found that the postovulatory follicles of California Quail (*Lophortyx californicus*) were difficult to identify with a dissecting microscope 10 days after ovulation had occurred. Observation of a postbreeding ovary revealed only that a female had laid many eggs.

Sixty-eight sexually mature female Franklin's Gulls were collected between the time of arrival on the colony during the last week in April to the time of departure during the third week in July. Changes in the size of the ovary and oviduct were compared with the laying frequencies shown in Fig. 10. It can be seen from Fig. 19 that the largest preovulatory follicles of the sexually mature Franklin's Gulls averaged 4 mm. in diameter upon their arrival in late April. The preovulatory follicles increased rapidly in size (to 20 to 25 mm.) during the second week in May and began to decrease during the third week in May. The period from May 15 to May 22 corresponds directly to the laying peaks in Fig. 10. The largest preovulatory follicles remaining after ovulation gradually atrophy and measured approximately 2 mm. by the third week in July, the time of departure.

Although the data collected in 1964 are somewhat incomplete, the peaks for all three years (1964, 1965 and 1966) appear to correspond quite closely. The laying means for the total number of eggs on the study areas (Fig. 10) show a peak three days earlier in 1964 than in 1965. An earlier increase in size does not appear in the preovulatory follicles for 1964 over 1965, possibly the result of incomplete data.

Fig. 19. Seasonal changes in size of the largest preovulatory follicle in Franklin's Gulls in 1964, 1965 and 1966.



100.0
80.0
60.0
40.0
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.5
DIAMETER OF PREOVULATORY FOLLICLES (MM)
1964
1965
1966
REPLACEMENT EGGS
APR
MAY
JUNE
JULY

Growth of Pre- and Postovulatory Follicles

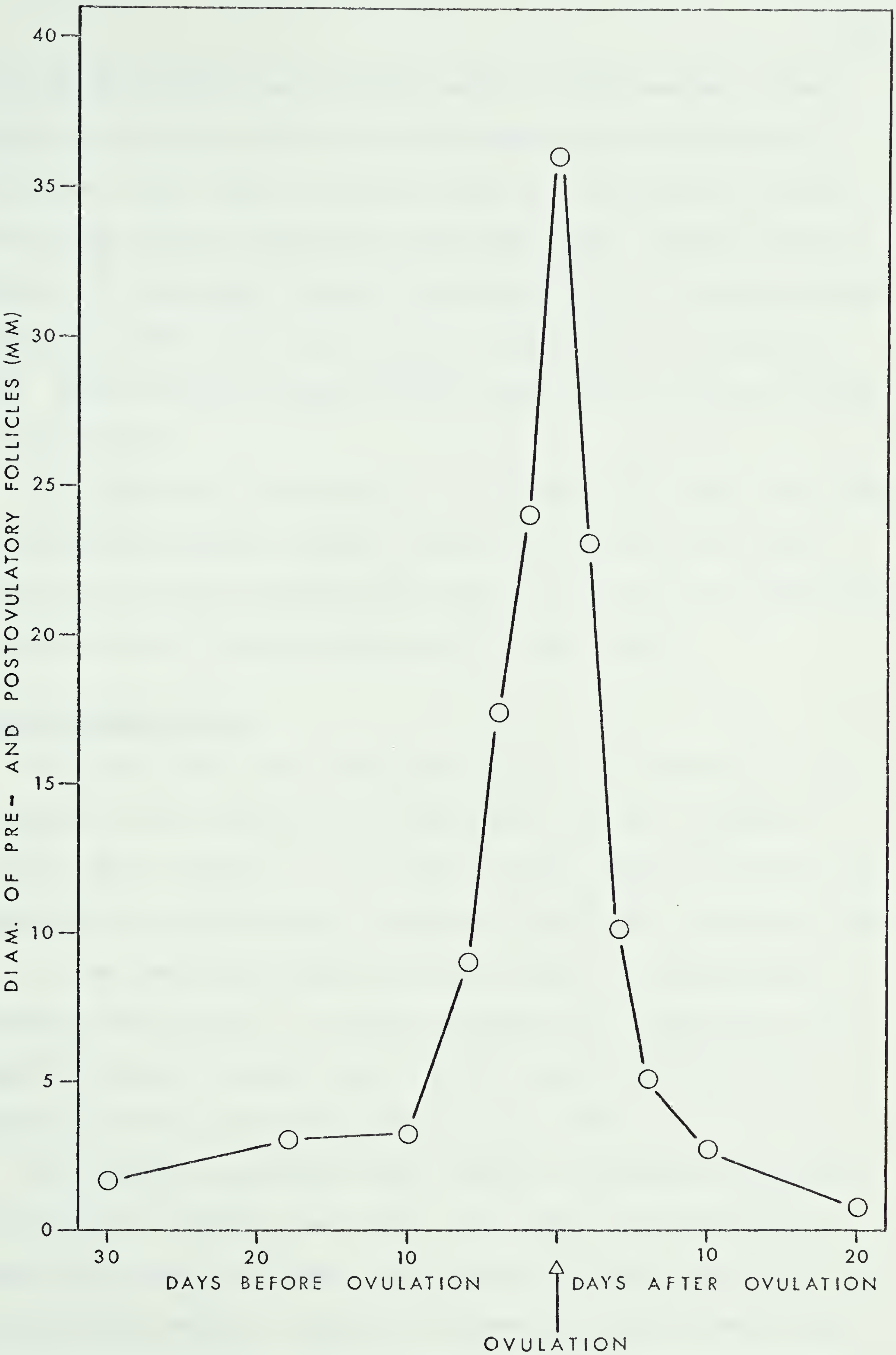
Lewin (1963) used the known rate of preovulatory follicular growth and the rate of postovulatory follicular involution to predict or postdate the laying of an egg or the laying period of the entire population.

The rate of growth of preovulatory follicles and the rate of involution of postovulatory follicles in Franklin's Gulls can be utilized to determine the approximate time of laying of either a single egg or laying for a population. If the laying date is known, the prediction of the growth curve of preovulatory follicles and the regression of the postovulatory follicles as shown in Fig. 20 is possible.

The diameters of all preovulatory follicles and the widths of all postovulatory follicles were averaged. The measurements were plotted on a graph according to the number of days from ovulation. The results can be seen in Fig. 20. The average diameter of all preovulatory follicles of sexually mature Franklin's Gulls at the time of arrival was 1.5 mm. The follicles gradually increased in size within 20 days to 3 mm. in size. Ten days before ovulation the final and most rapid growth of future ova occurred. Mature ova had diameters of approximately 36 mm. The postovulatory follicles became quite flat and rapidly involuted to 2.5 mm. in width within ten days after ovulation. Twenty days after ovulation the postovulatory follicles were 1 mm. in width. Beyond this period, they are too small to measure accurately with vernier calipers, and very difficult to recognize. Old postovulatory follicles became orange in color. Atretic preovulatory follicles are white.

Three Franklin's Gulls which had laid replacement clutches during the first part of June were collected in 1966. Inspection of the follicles

Fig. 20. Size of pre- and postovulatory follicles in 69 Franklin's Gulls in 1964, 1965 and 1966.



DIAM. OF PRE- AND POSTOVULATORY FOLLICLES (MM)
0
5
10
15
20
25
30
35
40
30
20
10
10
20
DAYS BEFORE OVULATION
DAYS AFTER OVULATION
OVULATION

revealed that clutches had been laid earlier in the same year. These correspond generally with the only replacement eggs discovered, laid on June 4, 5 and 6, 1965, as shown in Fig. 10. No laying had occurred on the study area for the previous four days. This, together with the discovery of replacement clutches through inspection of the three females collected in 1966, led to the conclusion that these were replacement eggs. They were laid 12 days after the laying mean for initial clutches at that location.

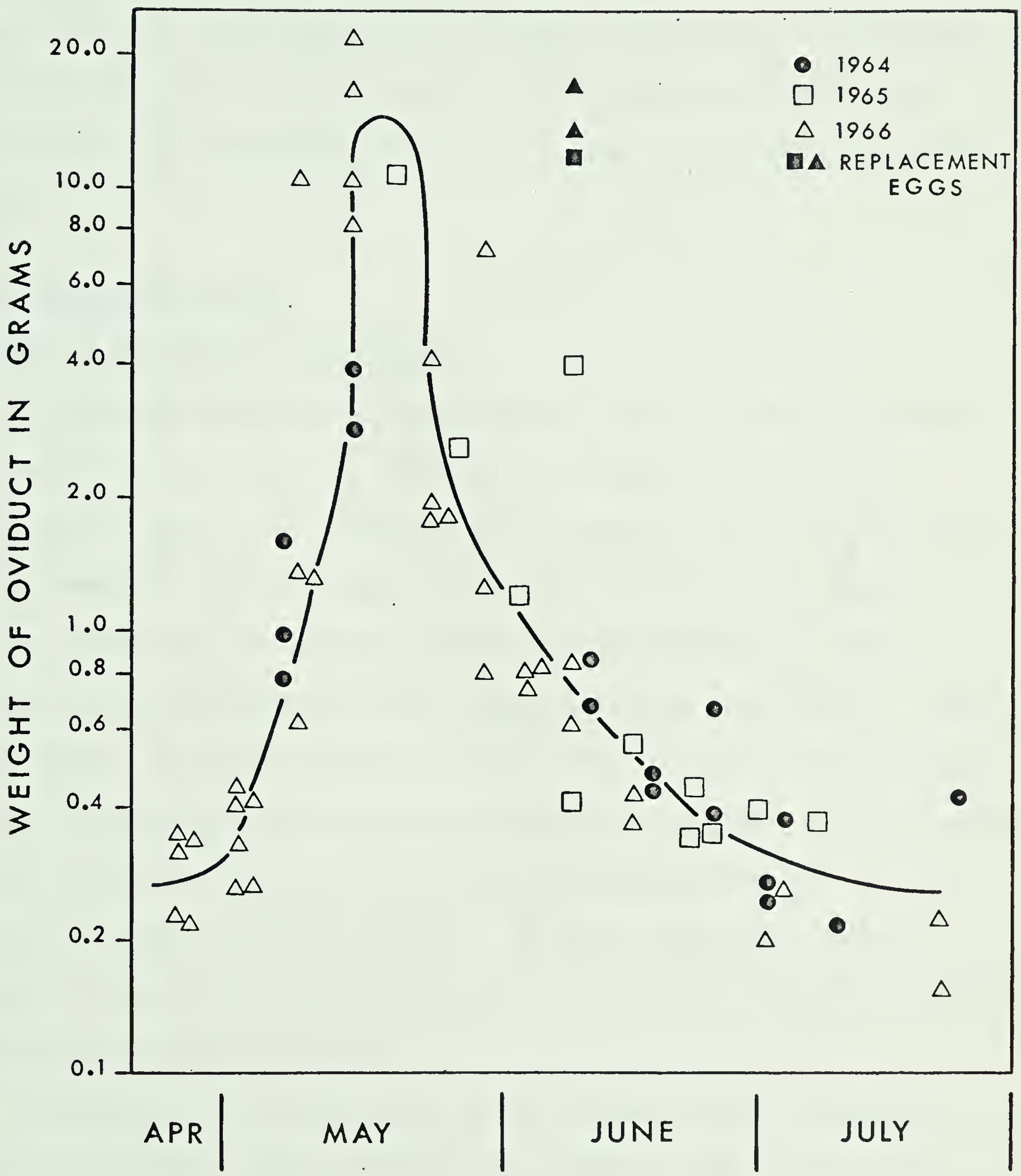
The examination of an ovary of a postbreeding gull under a dissecting microscope will ascertain whether a female has laid eggs and in most cases will reveal how many eggs have been laid. This may be accomplished in most cases until mid-July when the local gulls depart.

Seasonal Oviduct Cycle

Johnston (1956) found in California Gulls that there was an abrupt enlargement of the oviduct in the latter part of April, following an inactive winter condition. By the middle of May, after most adults were incubating, the oviduct began a noticeable regression. A diminished size of 3 to 4 mm. had been reached by the end of May, and was maintained throughout June and July. A similar enlargement and regression of the oviduct during the breeding season has been reported for Starlings (Bullough, 1942) and California Quail (Lewin, 1963).

The oviducts of Franklin's Gulls undergo a tremendous increase in size during the breeding season (Fig. 21). This organ increases its weight approximately 100 times. When these birds arrive, about April 25, the oviduct may weigh as little as 0.2 grams and on May 12 when laying has begun, it may weigh over 20 grams. The increase in size is much more

Fig. 21. Seasonal changes in weight of the oviduct in Franklin's Gulls in 1964, 1965 and 1966.



WEIGHT OF OVIDUCT IN GRAMS
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
1964
1965
1966
REPLACEMENT EGGS
APR
MAY
JUNE
JULY

rapid than its regression. Slower regression would allow the laying of replacement clutches, if initial clutches were destroyed. The oviduct measurements from three females which laid replacement clutches may be seen in Fig. 21. The weight of the oviduct at departure is 0.25 grams or almost the same as that on arrival. The date the oviduct reaches its maximum size corresponds closely to the mean laying date as previously shown.

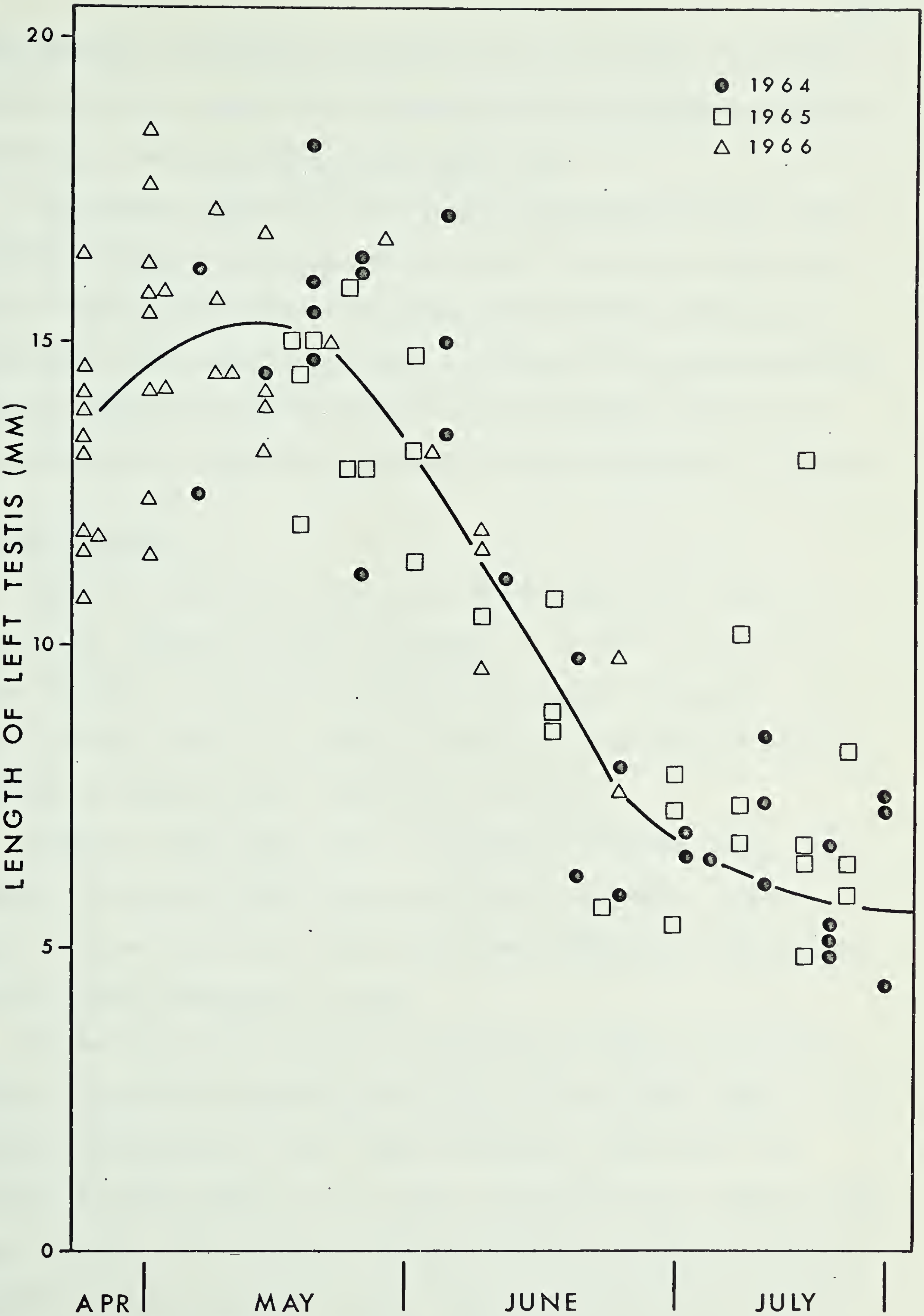
Male Reproductive Cycle

Growth and Regression of the Testis

Johnston (1956) found by measuring both the left and right testis in California Gulls that the left testis is largest in the greater percentage of males. He found that 84.7 percent of the left testes were longer than the right, 8.6 were smaller and 6.7 were equal. Johnston further states that in previous studies of this species only the left testes had been measured and, when compared with his own results, seemed to be valid. He found in 1951 that the testis in adult California Gulls begins a rapid increase in volume near the end of February and the beginning of March. The testis in these birds reaches its maximum size in early May, about the time of laying. The adult testes then begin to involute immediately after the eggs are laid in early May and reach their minimum winter size by October.

The length of the left testis for 95 sexually mature Franklin's Gulls was recorded. Fig. 22 depicts the change in size of the left testis during the breeding seasons of 1964, 1965 and 1966, taken from the time of arrival until the time of departure from the breeding grounds. Note that upon arrival in the latter part of April, the testis is already

Fig. 22. Seasonal changes in length of the left testis in Franklin's Gulls in 1964, 1965 and 1966.



1964
1965
1966
LENGTH OF LEFT TESTIS (MM)
20
15
10
5
0
APR
MAY
JUNE
JULY

well developed, averaging approximately 14 mm. in length. In contrast, it was shown that most of the development of the preovulatory follicles in females takes place after arrival (Fig. 19).

The average length of the left testis for Franklin's Gulls at its maximum development was approximately 15 mm. The testis reaches this size in mid-May, the time corresponding quite closely to the peak of the female cycles depicted in Figs. 10, 19 and 21. The testis decreases in size rapidly from mid-May to mid-June, reaching what appears to be its overwintering length of approximately 6 mm. by departure on July 20.

Sexual Dimorphism

Moynihan (1955) claims that in the Black-headed Gull there is a slight size difference between the sexes. If two birds are observed close together, he claims the difference is usually unmistakable. He noted that the head of the female is usually narrower than its mate and the bill is usually shorter than that of the male.

Johnston (1956) states that in collecting California Gulls, equal samples of males and females were not obtained each month. Field identification of the sex of the bird is very difficult in this species because sexual dimorphism is absent.

The male and female Franklin's Gulls are so similar in coloration that they cannot be separated by this means. Nice (1962), while studying the behavior of these birds in Manitoba, states that "G3 appeared from his behavior to be a male, G4 proved to be a female at her death in 1955." This suggests that Nice (1962) was unable to positively identify the sex of Franklin's Gulls except by dissection of individual birds after death. Dwight (1925) found very slight differences in size,

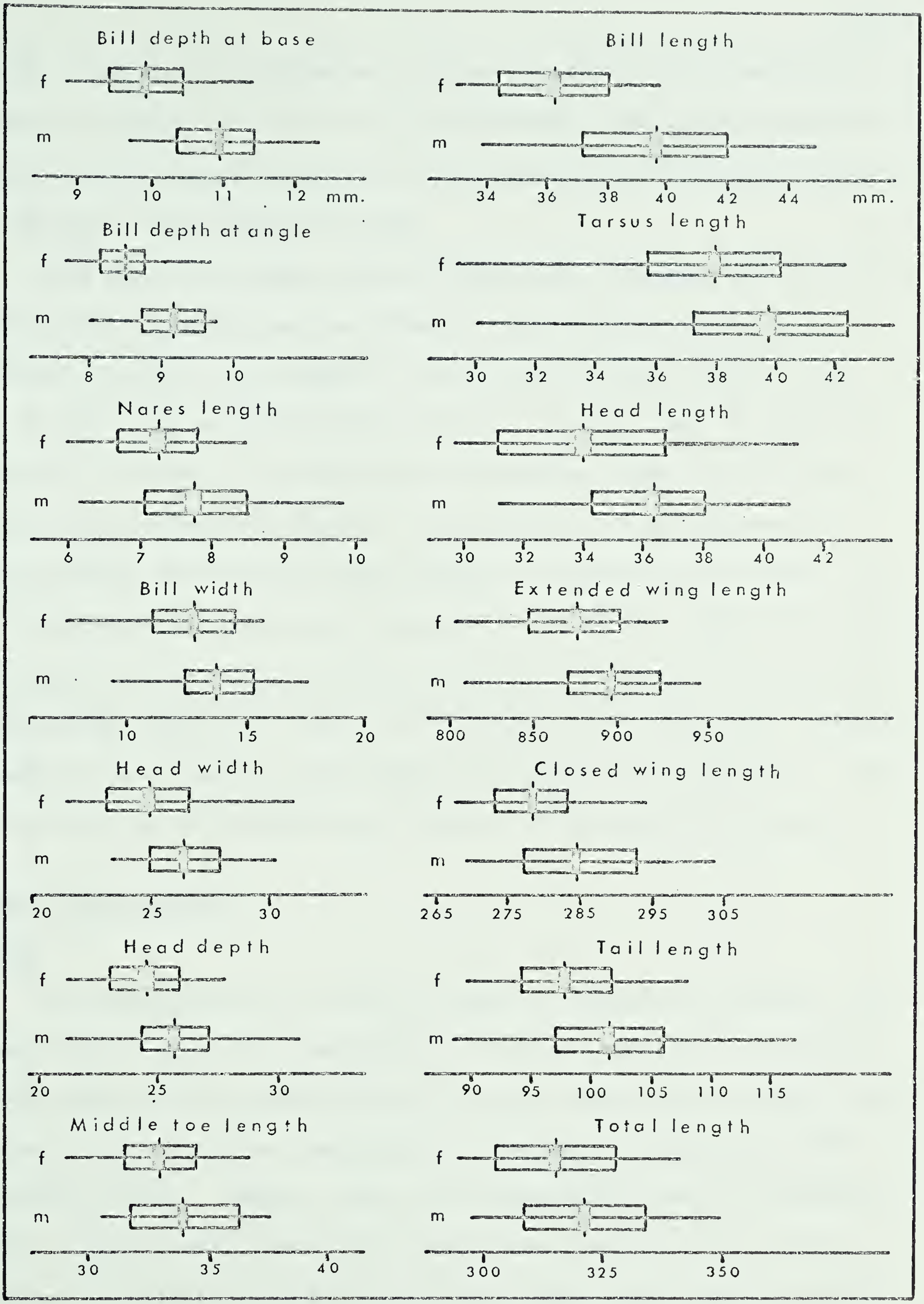
with the males being larger. He gives the following means and ranges in millimeters for 14 male and 12 female Franklin's Gulls: culmen of the female, 29.2 (27 to 33); culmen of the male, 30.7 (29 to 34); bill depth at base of female, 8.6 (8 to 9); and bill depth at base of male, 9.0 (8.5 to 10).

Sexual dimorphism does not appear to be present in gulls. In most other species of adult birds, one of the sexes, usually the male, is much more brilliantly colored than the other. In this study, there appeared to be no difference between the sexes in either the coloring or patterns of the wing tips. The only positive methods of identification of sex besides dissection were the observations of laying behavior and copulation. It was also noted that of the gulls which were collected, the males usually had been the more aggressive.

A total of 14 external measurements were taken from each of 100 adult male and 70 adult female Franklin's Gulls in an attempt to discover an external characteristic which would separate the sexes. For a detailed description of these measurements see Appendix I. The mean, standard error of the mean, range, and standard deviation are plotted for each measurement, by sex, in Fig. 23. In all 14 of these measurements, the male tends to be larger than the female. One measurement, "middle toe length," showed almost complete overlap between the sexes. The measurements which separated the sexes in most cases were the "bill depth," at both base and angle, and "bill length."

In the present study, bill length was measured from the tip of the bill to the angle of the mouth and cannot be compared with the culmen measure from Dwight (1925). Dwight's measurements of the bill depth at the base, however, are comparable. The author found that the bill

Fig. 23. Summary of fourteen external measurements for adult male and female Franklin's Gulls. The mean, standard error of the mean, standard deviation and range are given for each of these measurements from 100 males and 70 females. The letter "f" represents female and "m" male. For a detailed description of the external measurements see Appendix I.



Bill depth at base
f
m
9 10 11 12 mm.
Bill length
f
m
34 36 38 40 42 44 mm.
Bill depth at angle
f
m
8 9 10
Tarsus length
f
m
30 32 34 36 38 40 42
Nares length
f
m
6 7 8 9 10
Head length
f
m
30 32 34 36 38 40 42
Bill width
f
m
10 15 20
Extended wing length
f
m
800 850 900 950
Head width
f
m
20 25 30
Closed wing length
f
m
265 275 285 295 305
Head depth
f
m
20 25 30
Tail length
f
m
90 95 100 105 110 115
Middle toe length
f
m
30 35 40
Total length
f
m
300 325 350

depth at the base for 68 females averaged 9.9 (8.8 to 11.5) and for 100 males it averaged 10.9 (9.7 to 12.3) millimeters. The author's measurements for "bill depth" at the base appear to be larger than those given by Dwight in both average and range.

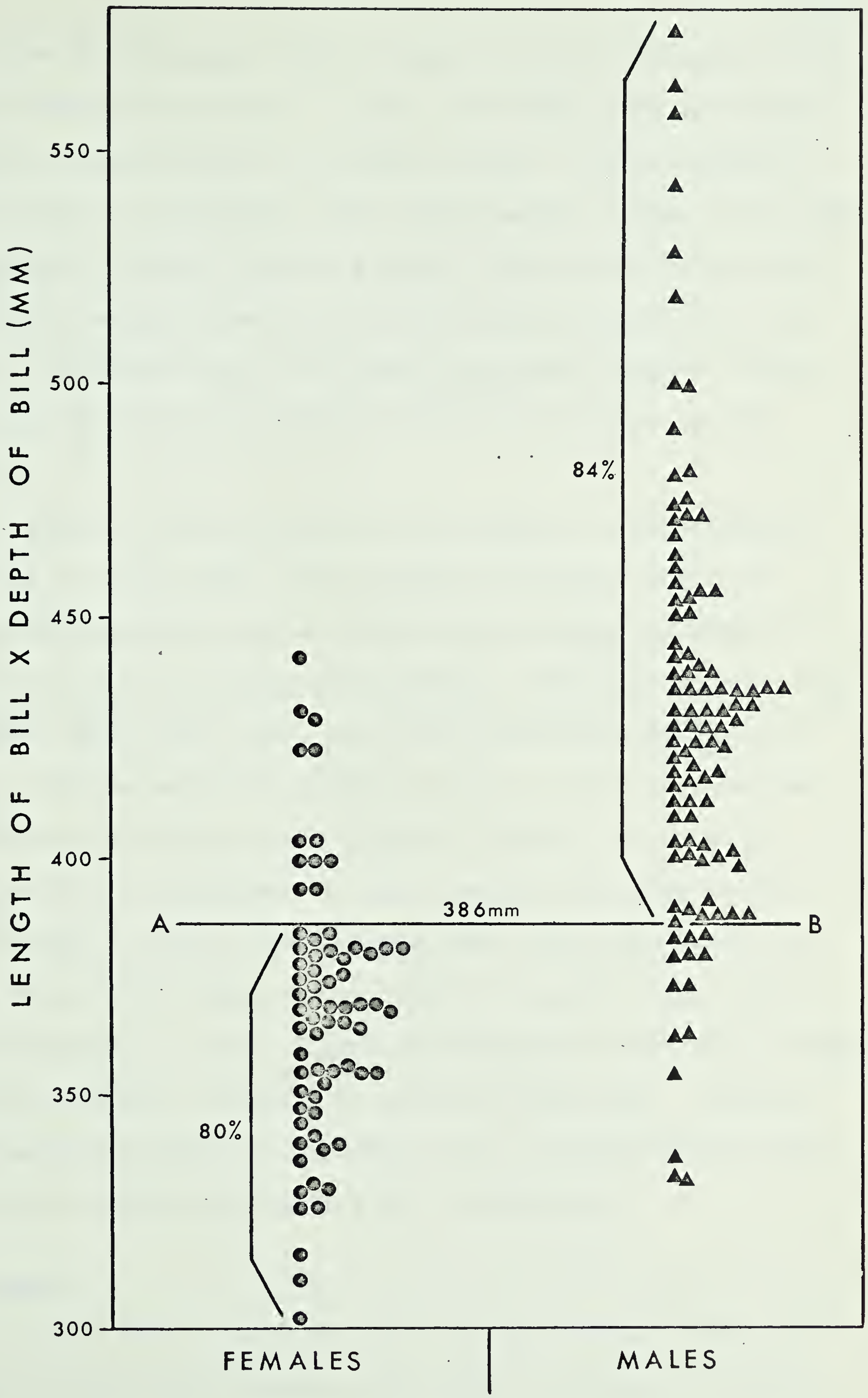
From Fig. 23 and other authors (Dwight, 1925; Ridgeway, 1919) it is evident that most external measurements do not separate the sexes. However, the bill of the female is shorter and narrower than the bill of the male. By multiplying the length of the bill times the depth of the bill, I obtained an index which separated the sexes in most of the cases, as illustrated in Fig. 24. The product of these measures was more reliable than the individual measures in separating the sexes. It was found that the best point of separation was 386 mm. Above this point 84 percent of the males occurred and below were 80 percent of the females. The maximum overlap was found to be 20 percent. Thus, with this indicator, Franklin's Gulls may be sexed fairly accurately without dissection. This should facilitate determination of the sex of live birds in the field.

Aging Characteristics

Bursa

Many investigators have used the bursa of Fabricius to determine the age of birds, especially game species. The bursa normally is prominent at an early age and generally becomes a small remnant when the birds reach maturity. This has been demonstrated for waterfowl by Hochbaum (1942) and Elder (1946). Johnston (1956) also demonstrated this for California Gulls. Elder (1946) found in the Canada Goose that the rate of bursal regression suggested that all geese do not attain sexual maturity at the same age. Johnston (1956) found a general trend toward reduction of

Fig. 24. Bill index for adult female and male Franklin's Gulls. Length was measured from the tip to the angle of the mouth and depth, including the upper and lower mandible, was measured at the feather line.



LENGTH OF BILL X DEPTH OF BILL (MM)
550
500
450
400
350
300
84%
80%
A
B
386mm
FEMALES
MALES

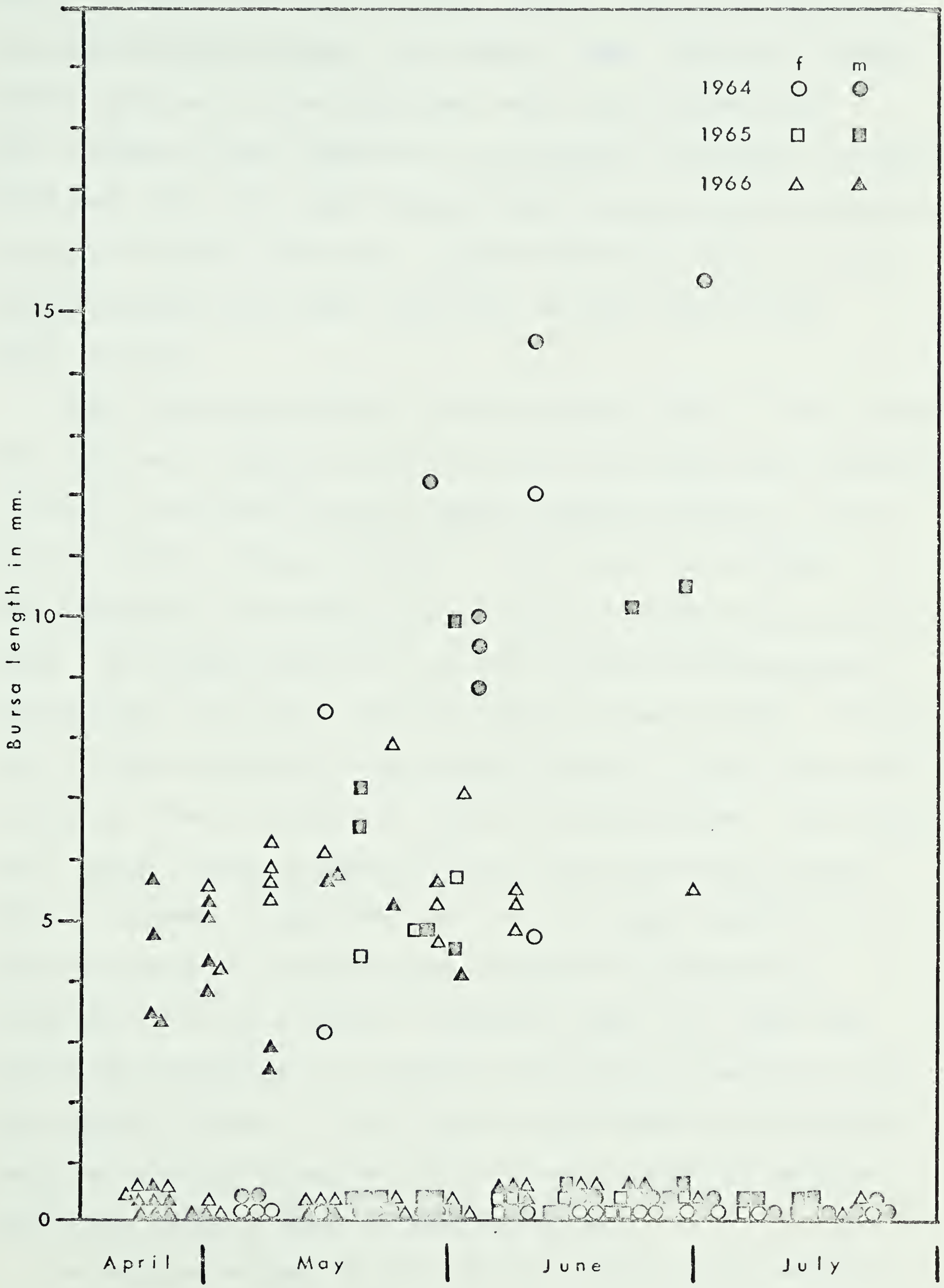
bursal size from first-year birds to those in their second year, further reduction from the second year to those in the third year, and further reduction in the third year to the adult age class. Upon attainment of maturity there is a continuing trend towards general atrophy of the bursa in older birds. He also found as a general rule that third-year birds which were breeding had smaller bursae than non-breeding birds of the same age. Some exceptions to the general trend were reported: bursal absence in some third-year California Gulls and persistence in some adults.

The lengths of bursae present in 169 Franklin's Gulls collected from April to July in 1964, 1965 and 1966, were plotted in Fig. 25. Since no differences were found between bursae of males and females or from year to year, all samples were combined. All bursae which persisted as a small remnant (less than 1 mm.) were plotted along the bottom of Fig. 25. The specimens which lacked any sign of a bursa were omitted. All these specimens were sexually mature. From Fig. 25, it can be seen that there is an increase in bursal length in the younger adult birds from April to July. The specimens with a bursa less than 1 mm. long or those with no bursa were all found to be mature birds. Since no known-age birds or means of aging adult Franklin's Gulls were obtained, it was not possible to separate the birds into age groups. If bursal length had been recorded for the entire year, it would probably reveal a decrease in length beginning in August and September.

Wing Classes

In June of 1964 at Hay Lakes, 1,132 juvenal Franklin's Gulls were banded in the hope that known-age birds might be recovered in 1965 and

Fig. 25. Seasonal changes in the length of the bursa in sexually mature Franklin's Gulls collected in 1964, 1965 and 1966.



f
m
1964
1965
1966
15
10
5
0
Bursa length in mm.
April
May
June
July

1966. No banded birds were recovered. However, three age classes can be readily separated (Dwight, 1925; Godfrey, 1966). These are: mature adults, which have a slate black head, white tail, dark red bill, dark red legs and feet; immatures, or one-year-olds, which have a brownish black head, white tail, black bill and black legs and feet; and juveniles, or young of the year, which have a grayish brown head, white tail with a broad subterminal black band, brown bill, and brown legs and feet (Figs. 3 and 4).

While collecting specimens of adult Franklin's Gulls, it was observed that there was a variation in the coloration of the wing tips. The amount of black in the tips of the two outermost primaries appeared to occur in various patterns. Young of the year, at the time of first flight, are easily recognized. The entire tips of their two outermost primaries are black. The sexually immature or one-year-old birds have approximately three-fourths of the tips of the two outermost primaries black. The wing tips of these one-year-old birds are quite similar to those of wing class I, Fig. 26. These two groups of birds are easily separated. The problem was to obtain a means of aging birds after they reach sexual maturity, which is believed, in most cases, to be from two years and older. The author separated all sexually mature Franklin's Gulls which were collected into six wing classes, I through VI (Fig. 26). These wing classes were determined by the amount of black color on the tips of the two outermost primaries. Class I has the maximum amount of black which decreases in amount through the various classes to Class VI, which has the minimal amount of black, as noted in Fig. 26.

As mentioned earlier, the bursa has been used as an age criterion for numerous species of birds. In Fig. 27, bursae lengths longer than

Fig. 26. Wing classes of sexually mature Franklin's Gulls. Note the amount of black coloration in the tips of the outermost primaries. Wing class I has the maximum amount of black which decreases to the condition depicted in wing class VI.

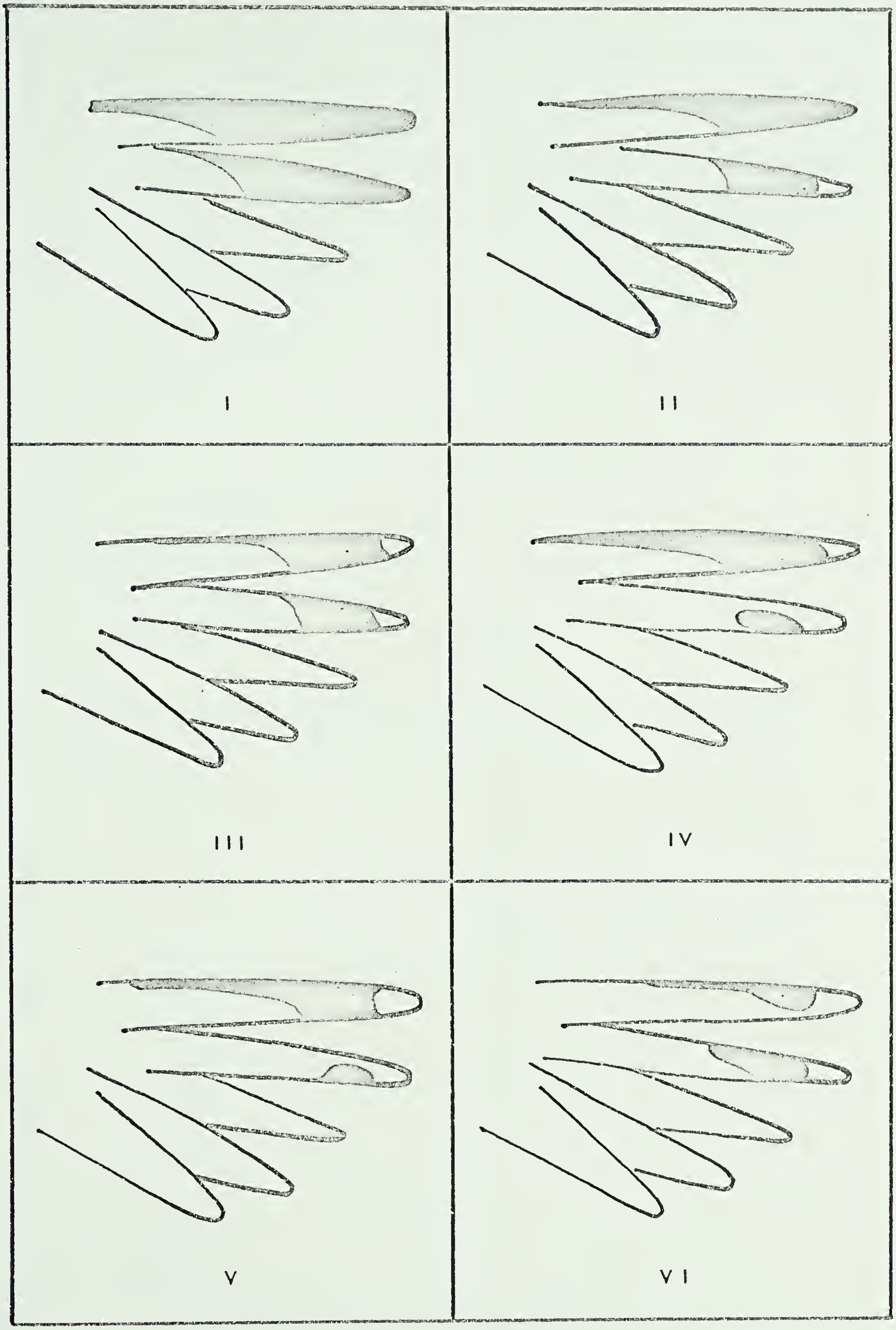
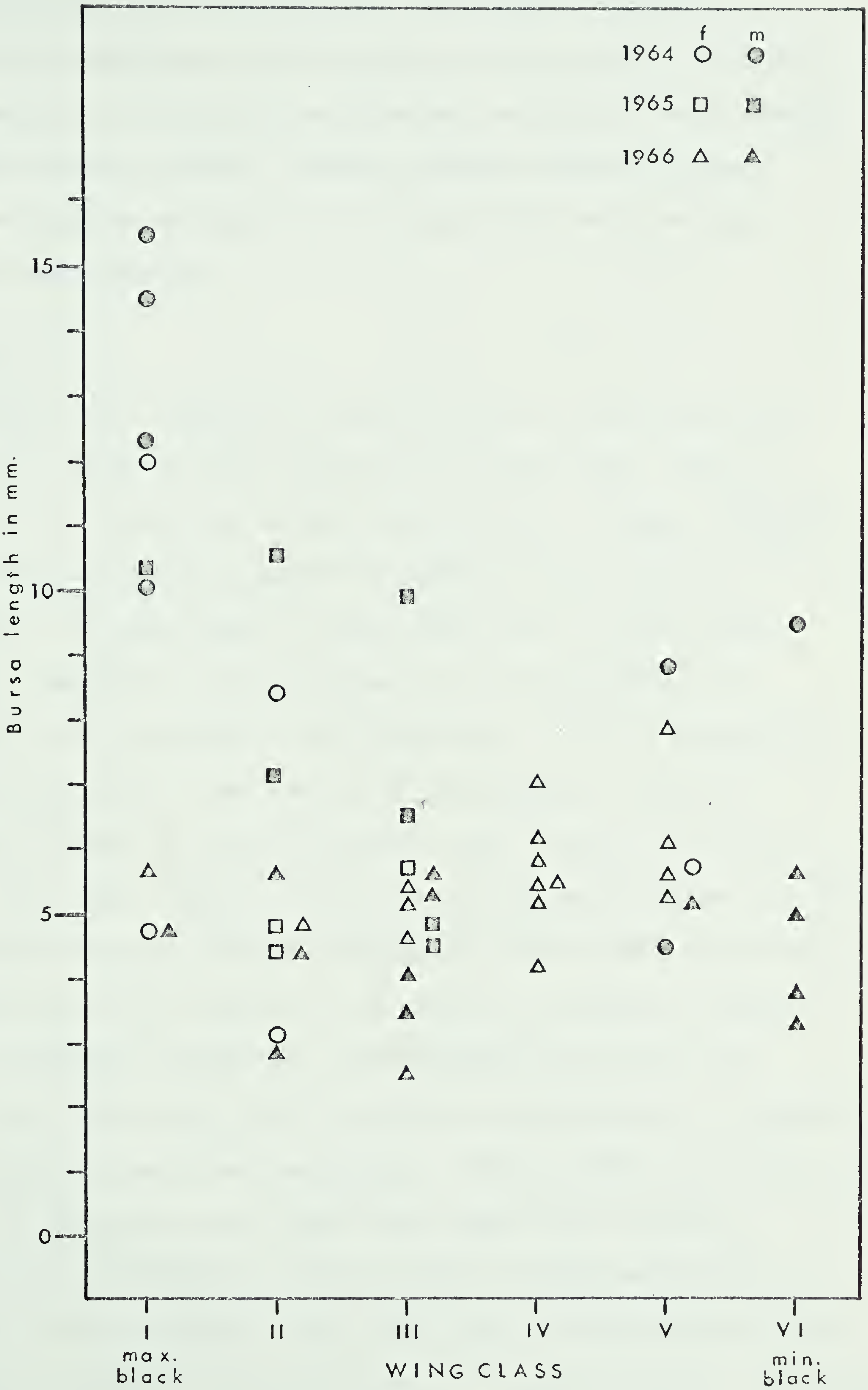

I
II
III
IV
V
VI

Fig. 27. Relationships between wing classes and length of bursa in sexually mature Franklin's Gulls collected in 1964, 1965 and 1966.



f
m
1964
1965
1966
Bursa length in mm.
15
10
5
0
I
II
III
IV
V
VI
max.
black
WING CLASS
min.
black

1 mm. are plotted against wing classes. This figure suggests a relationship between longer bursal lengths and wing class I, which has the maximum amount of black on the primaries, and shorter bursal lengths with lesser amounts of black. The wing classes correlate with age, however, no definite conclusions can be made until some known-aged birds have been collected.

Food Habits

Collinge (1927) studied the stomach contents of 644 Black-headed Gulls, most of which had been collected in Scotland over a period of three years. For the months of April through July, a study of 298 specimens revealed that insects composed 40 percent of the total food of these birds. The percentages of insect food items were distributed as follows: Hemiptera (0.5), Plecoptera (0.5), Trichoptera (0.5), Coleoptera (61.5), Lepidoptera (19), Hymenoptera (2.5) and Diptera (15.5). The Black-headed Gull's diet consists of approximately one-half as much insect material as that of Franklin's Gulls, which is 88 percent insects (Table XII). However, Coleoptera contributes the largest quantity of insect food material for both species, 61 and 46 percent respectively.

Many writers have remarked on the ability of Franklin's Gulls to control grasshoppers and prevent their reaching destructive levels. Bradhaw (1934) and Gardner (1927) both mention observations of Franklin's Gulls feeding on grasshoppers and locusts. DuMont (1941) states with reference to these birds that they "feed largely over or near-by agricultural land and must be a great factor in insect destruction, principally of grasshoppers." Nice (1962) states, "the Franklin's Gull..., which nests abundantly on the Delta Marsh, is a prairie species, subsisting

Table XII. Food material from 27 adult Franklin's Gulls collected at Hay Lakes, Alberta, in 1966.*

No. of gulls	3	3	3	2	4	2	2	2	2	2	2	
Date	April		May				June			July		
	25	2	13	24	31	9	16	25	1	9	21	Total
Invertebrate												
Oligochaeta	1(1)											1(.1)
Arachnida									1(T)			1(T)
Insecta												
Odonata+						1(8)			1(T)			2(.8)
Zygoptera	1(11)							1(11)				2(2)
Hemiptera												
Corixidae	1(T)	2(4)	2(28)	1(T)		2(34)						8(7)
Notonectidae			2(T)									2(T)
Gerridae		2(T)	1(T)									3(T)
Pentatomidae										1(T)		1(T)
Cydindae										1(T)		1(T)
Coleoptera+									1(16)	1(24)		2(3)
Carabidae		1(T)	1(T)			2(4)	1(57)		2(10)	1(60)		8(13)
Dytiscidae	2(9)	3(73)	1(T)			2(T)		1(T)	1(T)		1(T)	11(16)
Staphylinidae						1(T)						1(T)
Hydrophilidae		2(1)				2(31)			2(T)	1(T)		7(3)
Silphidae									1(T)			1(T)
Elateridae							1(T)	1(T)				2(T)
Scarabaeidae			1(3)		1(T)	1(5)		2(73)	1(68)	1(10)		7(11)
Curculionidae										1(T)		1(T)
Byrrhidae										1(2)		1(.1)
Trichoptera+	1(8)											1(1)
Phryganeidae	1(6)											1(.9)
Lepidoptera+											2(75)	2(1)
Diptera+									1(T)			1(T)
Tipulidae									1(T)			1(T)
Chironomidae	1(22)		1(10)		1(42)	1(T)	1(29)					5(12)
Hymenoptera												
Ichneumonidae						1(T)						1(T)
Formicidae										1(2)		1(.1)
Unidentified	1(25)	2(20)	1(31)			2(17)	1(12)					7(16)
Mollusca			1(9)									1(1)
Vegetation												
Seeds	1(T)		1(18)		1(T)					1(1)		4(2)
Grit	2(1)	1(1)		2(32)	2(13)	1(T)	2(1)	2(2)	1(T)	1(T)	1(9)	15(2)
Debris	2(16)			1(67)	3(44)			1(13)	1(5)		1(14)	9(7)

*The first figure represents the number of gulls in which the food material occurred. The figure in parenthesis indicates the percentage of the total content by volume for that collection period. "T" represents trace (less than 0.1 ml.). "Unidentified" material could only be determined to the Class Insecta.

+These could only be identified to Order.

largely on grasshoppers in the summer." The basis for Nice's observation was not mentioned.

Rothweiler (1960) identified food items from 108 Franklin's Gulls collected from April through September in 1958 and 1959 at Freezout Lake, Montana. He found that, by far, the most important food items for these birds were insects. He recorded the following frequencies in percent of insect families: Corixidae, 25; Carabidae, 43; Dytiscidae, 23; Hydrophilidae, 16; Scarabaeidae, 73; and Chironomidae, 33. In April, May and June, Scarabaeidae was the most abundant food in gull crops or stomachs, shifting to Carabidae and Formicidae in July. He found, as was discovered at Hay Lakes, that wheat and barley were the most frequent vegetative food items. Franklin's Gulls at Freezout Lake had ingested the following food material which was different from that at Hay Lakes: Orthoptera, Amphibia and unidentified vertebrates (Rothweiler, 1960).

Franklin's Gulls obtain most of their food on the wing through the capture of airborne insects. Feeding occurred over the study areas and the adjacent land under cultivation. Soft-bodied forms of insects would account for the large quantity of "unidentified" insect material, since they would be rapidly ground up.

A total of 27 adult Franklin's Gulls in 1966 were analyzed for food items. When the gulls arrived in the latter part of April, an average of one male and one female were collected at weekly intervals until departure in the latter part of July. Whenever possible, the invertebrate food material was classified to Family. In Table XII, the division "unidentified" refers to material which was so pulverized that recognition beyond Insecta was impossible. "Vegetation" consisted mostly of grain, primarily wheat and barley. "Grit" includes primarily

the small stones utilized in grinding up food. The category of "debris" included miscellaneous items such as garbage and, in most cases, mud. The final column in the table represents the total number of specimens in which the food material occurred, followed by the percentage of the total content by volume for all 27 specimens. Since there appeared to be no difference in food items eaten by male or female adult gulls, the sex of each gull collected was not included in Table XII.

From Table XII, it can be seen that the volume of total food items for the entire collection period consisted of insects, 88 percent; debris, 7; vegetation, 2; grit, 2; and other invertebrates, 1. The insect material present can be subclassified as follows: Coleoptera, 46 percent; Diptera, 12; Hemiptera, 7; Odonata, 3; Trichoptera, 2; Lepidoptera, 1; Hymenoptera, 1; and unidentified insects, 16. Further calculations of my data to frequency of occurrence were made in order to make comparisons with Rothweiler's (1960) findings, which were given in frequency of occurrence but not by volume. Of the gulls collected at Hay Lakes, the following frequencies of insect items for all birds were: Corixidae, 30 percent; Carabidae, 30; Dytiscidae, 41; Hydrophilidae, 26; Scarabaeidae, 26; and Chironomidae, 19.

The sequence of insect food items may be described on a monthly basis over the breeding period. For the Hay Lakes study, Dytiscidae was the most frequent insect food and Chironomidae had the largest volume over the entire breeding season. During the month of May the gulls ingested primarily Dytiscidae, then Corixidae and finally Chironomidae. The following month they began eating mainly Corixidae and progressed to Carabidae and finally Scarabaeidae at the end of June. During the month of July, the gulls began with greatest quantities of Scarabaeidae, progressing to

Carabidae and finally ending with Lepidoptera.

The results appear to be similar for food items from gulls collected at Hay Lakes, Alberta by the author and at Freezout Lake, Montana by Rothweiler (1960), for identical collection periods, April through July. The six most frequent insect families represented in Rothweiler's study were also the most frequent from Hay Lakes. The lack of Orthopterans from the Hay Lakes gulls is both a function of a low incidence of these insects in this particular area and their hatching time of late July, which occurred at the end of the sampling period. Small mammals, such as shrews and mice, were ingested by Franklin's Gulls as observed by the author. Hay Lakes gulls had ingested mollusks (snails); Freezout Lake gulls had not. Franklin's Gulls in both locations had eaten similar miscellaneous foods, such as vegetation, grit and debris. The differences between these two studies and also from earlier findings may represent the varying availability of food materials among locations.

Pesticide Residues

It has been found that Bobwhites (Colinus virginianus) fed insecticides lose weight, due to a loss of appetite, and weight loss is generally more pronounced and of longer duration for insecticides administered at higher levels (Dahlen and Haugen, 1954). It has been reported by Stickel, Hayne and Stickel (1965) that if Woodcocks (Philohela minor) containing sub-lethal doses of pesticides are starved, they will show pesticide poisoning symptoms before dying.

Cooch (1964) found that Mallards (Anas platyrhynchos) which laid eggs containing only 2 p.p.m. DDT had significantly lower hatching success than eggs without residues. Lockie and Ratcliffe (1964), studying the

eggs of Golden Eagles (Aquila chrysaetos) in Scotland, found no evidence that insecticide residues of Dieldrin below 1 p.p.m. had any noticeable effect on hatching success. Stickel et al. (1965) found that one Woodcock containing 7.9 p.p.m. DDT in its tissues died during a ten day semi-starvation period.

In Herring Gulls, Keith (1966) found that of 115 nests from Lake Michigan, between 30 to 35 percent of the eggs did not hatch. He collected a sample of nine eggs from this colony and analyzed for insecticide residues. It was found, by calculation on a wet weight basis, that the eggs averaged 19.0 p.p.m. of DDT, 202.0 of DDE and 6.0 of DDD.

Vermeer (1967) found that California and Ring-billed Gulls at Miquelon Lake, Alberta contained mean residue contents in the brain of 2.6 p.p.m. DDE, 0.25 DDD, and 0.07 DDT, and 23.0 p.p.m. DDE, 0.12 DDD and 0.06 DDT, respectively. The equivalent figures for the uropygeal gland were 20.0 p.p.m. DDE, 0.38 DDD, and 0.16 DDT for California Gulls and 30.0 p.p.m. DDE, 0.40 DDD, and 0.14 DDT for Ring-billed Gulls. Vermeer's study showed higher residue levels of DDE, DDD and DDT in the brain, than those of Franklin's Gulls upon arrival at the breeding ground in the spring (Table XIII). He found levels of DDE in the uropygeal gland in California and Ring-billed Gulls that were higher and levels of DDD and DDT that were lower than those in Franklin's Gulls. Vermeer (1967) believes that insecticide residues were not responsible for infertility or embryonic deaths in California and Ring-billed Gulls at Miquelon Lake, Alberta.

During the summer of 1966, Franklin's Gulls were collected and sent for an analysis of pesticide residues. Thirty eggs and 26 of each of the following groups were analyzed: adult gulls at arrival on the colony;

Table XIII. Average levels of pesticides in parts per million from tissues of Franklin's Gulls.

	Dieldrin	DDE	DDD	DDT	Total°
Adults (Arrival)*					
UPG⁺	0.992	2.180	0.641	1.114	4.779
L	0.215	0.424	0.091	0.244	0.919
GIT	0.138	0.261	0.142	0.150	0.572
B	0.094	0.396	0.128	0.574	0.998
Adults (Departure)					
UPG	0.395	2.039	0.502	0.630	3.346
L	0.100	0.371	0.136	1.109	1.409
GIT	0.051	0.191	0.106	0.108	0.415
B	0.053	0.225	0.188	0.204	0.563
Young (Living)					
UPG	0.455	0.558	0.713	1.359	2.122
L	0.053	0.065	0.062	0.110	0.190
GIT	0.054	0.039	0.044	0.079	0.114
B	0.022	0.092	0.179	0.165	0.351
Young (Dead)					
B		0.229	T		0.229
Eggs					
	0.293	0.462	T	0.006	0.755

*Each sample of birds consisted of twenty-six specimens; the eggs numbered thirty.

⁺Symbols: UPG, uropygeal gland; L, liver; GIT, gastrointestinal tract; B, brain. Young (Living) were birds found alive and collected; Young (Dead) were birds found dead.

°Total pesticide values as equivalents of DDT.

TTraces below the limit of detection (less than 0.001 p.p.m.).

adults at departure from the colony; live young; and dead young. Pesticide residues were determined for the uropygeal gland, liver, gastrointestinal tract and brain. Mesenteric fat was not present in large enough quantities to be analyzed. The dead young had only the brain tissue analyzed. All the samples were analyzed for the following residues: Lindane, Heptachlor, Aldrin, Telodrin, DDT, DDD, DDE, Dieldrin, Endrin and Methoxychlor. Of these, only Dieldrin, DDT and its breakdown products DDD and DDE were present.

Table XIII shows the results of the pesticide analysis. Generally, the adult gulls had much less Dieldrin, DDE, DDD and DDT upon departure than upon arrival, with the exception of some residues of DDD and DDT in the liver and residues of DDT in brain tissue. This would indicate that residues had been passed to and filtered out by the liver. The combined total of all residues of the adults showed a lower level at departure in most tissues, with the exception of the liver. At arrival the brain level was 0.998 p.p.m. and at departure it had lowered to 0.563 p.p.m. This would support the belief that more pesticide residues were obtained on their wintering grounds and migration route than on their breeding grounds. However, birds with greater residues may have died before departure.

When the residues of the living young were compared with those of adults at departure, the young birds contained an 80 percent lower pesticide level than did the adults. The combined total of all residues is less for the living young than either group of adults. DDE was found to be more concentrated in the brain tissue of young birds found dead than in the live young. However, the live young were found to have a greater combined total of all residues in the brain tissue than did the

dead young.

Eggs contained the following levels of residues: DDE, 0.462 p.p.m.; DDT, 0.229 p.p.m.; and Dieldrin, 0.293 p.p.m. Only one gull egg was collected that had a level as high as that reported by Cooch (1964); it had 2.114 p.p.m. of DDT. The average level of DDT in eggs was 0.755 p.p.m. No evidence was found of low hatching success due to pesticides.

The highest pesticide residue obtained from a single Franklin's Gull was an adult which had 20.800 p.p.m. of DDT in its liver at the time of departure from its breeding ground. The highest level obtained from a young gull was a live bird which had 15.171 p.p.m. of DDT in its uropygeal gland.

It is apparent from Table XIII that pesticide residues accumulated in certain tissues more than in others. The tissues, ranked from greatest concentration to the least, are as follows: uropygeal gland, liver, brain and gastrointestinal tract. Since all of these pesticides act primarily on the nervous system, the values reported for the brain are probably the most important.

There was no evidence of mortality in Franklin's Gulls due to the direct effect of pesticides. However, many juveniles appeared to behave abnormally on various occasions. Young which appeared very active, later became inactive. As previously mentioned, many young which were being weighed daily in order to construct a growth curve would begin to lose weight for a period of several days just prior to death. When examined, these gulls showed no signs of external injuries or abnormalities. The combined level of all residues in the brain obtained from a sample of dead young was 0.229 p.p.m. This is below the lethal dosage level for Woodcocks stated by Stickel et al. (1965). Some of the juvenal gulls,

as they were dying, showed the following symptoms: listlessness, tremors and uncoordinated muscular activity. These symptoms are characteristically seen in birds poisoned by chlorinated hydrocarbons (Rudd, 1964). It was noticed that the young which lost weight just prior to death failed to regurgitate food when picked up for weighing. This possibly indicates that no food was being obtained. It is possible that the juvenal gulls, because of abandonment by their parents, had to obtain their own food and hence may have starved. Thus starvation may have allowed sub-lethal residue levels to become lethal. More research is needed on Franklin's Gulls to determine the relationships between pesticide residues and starvation.

CONCLUDING DISCUSSION

Franklin's Gulls appear to be very similar to European Black-headed Gulls in those phases of the breeding biology which have been studied.

In size, Franklin's Gulls would appear quite similar. Dwight's measurements (in millimeters) for the "culmen" and "bill depth at base" for both species are as follows: female Franklin's Gull culmen, 29.2 (27 to 33), male culmen, 30.7 (29 to 34); equivalents for Black-headed Gulls are 31.5 (30 to 33) and 33.6 (31 to 37). The bill depth at base was: female Franklin's Gull, 8.6 (8 to 9) and male, 9.0 (8.5 to 10); equivalents for Black-headed Gulls are 8.1 (8 to 8.5) and 8.8 (7.5 to 9.5).

The plumages in the three age classes, juveniles, one-year-olds and adults, are very similar in both of these species. Juveniles of both birds have grayish brown heads and white tails with a broad subterminal black band. The coloration, however, of bills, legs and feet differs between the two species. Juvenal Franklin's Gulls have brown bills, legs and feet, while juvenal Black-headed Gulls have flesh-colored bills, legs and feet.

The heads of the one-year-old gulls of both species are partially colored in brownish gray and both have white tails. The bills, legs and feet of Franklin's Gulls are black while Black-headed Gulls have reddish colored bills, legs and feet.

The adults of both species have white tails and dark red bills, legs and feet. The head of the adult Franklin's Gull is slate-black and that of the adult Black-headed Gull is brown.

Both species select similar nesting habitats, inland marshes and

lakes. Both are colonial breeding species, preferring nesting sites within a few feet of open water. Both species are almost identical with regard to clutch size, laying intervals, incubation shifts, incubation periods and embryo growth.

The two major areas of differences appeared to be in feeding habits and overall reproductive success. The Black-headed Gull's diet consists of only 40 percent insects, contrasted with 88 percent for Franklin's Gulls. This may be a function of the availability of food items at a particular location. The other major difference is the higher overall reproductive success of Black-headed Gulls. This seems to be a result of the favorable adaptation of this species to human influence. Black-headed Gulls appear to be less affected by human disturbance than Franklin's Gulls. This may be a result of the proximity of the Black-headed Gull colonies to large human population centers. Franklin's Gull colonies in Canada, in most cases, are isolated and are some distance from human population centers. Black-headed Gulls probably have adapted to human disturbance which has existed for some time in most European countries.

In view of the many similarities between *Larus pipixcan* and its European relative, *Larus ridibundus*, the author would like to suggest that they are more closely related than presently regarded and that they might be considered as being conspecific.

SUMMARY

A study of the breeding biology of Franklin's Gulls, Larus pipixcan, was carried out in central Alberta during the breeding seasons of 1964, 1965 and 1966. Very little information is available at present for this species. Therefore, the primary objective of the study was to expand knowledge of the breeding biology so that a comparison could be made with various old world gulls, primarily the Black-headed Gull.

The most important limiting factor for reproductive success appears to be the amount of precipitation prior to and during the breeding season. The gulls will not nest is weather conditions are such that emergent vegetation is not present during the breeding season. A prerequisite for the initial stage of nesting is the presence of emergent vegetation, either Scirpus acutus or Typha latifolia. If prolonged periods of cold weather and/or heavy precipitation occur, during any one of the following periods: laying, incubation, hatching, and growth of young, productivity probably will be lowered. Long periods of heavy precipitation, such as occurred between June 26 and 28, 1965, result in a rise in water level. The effect of the rise of six inches in June, 1965 was a dismantling of nests, followed by a loss of eggs into the water. Heavy precipitation, accompanied by low air temperatures, may result in the death of many chicks from exposure. This lowered the reproductive success in June, 1965 by 15 percent.

The prime nesting sites are those nearest to open water. Nests are constructed on foundations of the previous year's growth of dominant emergent vegetation. The same vegetative remnants are used for nest-building material. The average density of nests was one nest per 80.7 square feet.

Laying began on May 12, 1965 and lasted 21 days, with the mean occurring on May 21. The laying means for 1964 and 1966 were May 18 and 22, respectively. Both the laying of replacement clutches by adults and laying by one-year-old gulls occurred. The laying interval between egg I and egg II was 2.35 days and between egg II and egg III was 1.96 days. The average clutch size was 2.16 and the average egg size was 36.07 by 51.92 mm.

The average length of incubation for all eggs was 24.6 days. Incubation began with the laying of the first egg, but increased in intensity after completion of the clutch. Both sexes shared in incubation duties. The average incubation shift was two hours and 39 minutes.

The period of most rapid weight increase of embryos occurred between 6 to 10.5 days, a doubling in weight occurring every $1\frac{1}{2}$ days. There was a decline in the rate of weight increase from day 10.5 to day 13; a doubling during this period required $2\frac{1}{2}$ days. This was followed by a brief return to the former rate, a doubling during a $1\frac{1}{2}$-day period, from day 13 to day 14.5. The remaining rates of increase steadily declined. The largest embryos were not necessarily produced by the largest eggs.

The hatching period in 1965 began on June 9 and lasted 17 days, with a mean occurring on June 15. The mean hatching date in 1964 was June 16.

Two-thirds of all eggs laid did not hatch. Of these, the greatest loss, 66 percent, was due to predation by Franklin's Gulls. Areas of minimal disturbance showed only a 25 percent egg loss. The major cause of death in the young gulls appears to be from pecking by adults. Young birds that wander onto the nesting territory of neighboring gulls are either driven away or pecked to death.

All aspects of reproduction were more successful in 1964 than in

1965. The average clutch size in 1964 was 2.2 and in 1965 it was 2.1. The hatching success in 1964 was 1.69 young per clutch or 75.7 percent and in 1965 it was 1.27 young per clutch or 60.4 percent. The fledging success in 1964 was 0.34 young per clutch or 20.4 percent and in 1965 it was 0.16 young per clutch or 12.2 percent.

The average weight and age at fledging, or first flight, were 269 grams and 30 days, respectively.

Human disturbance by the author on the study areas definitely lowered the reproductive success. The most critical disturbance occurred during nest-marking activities. The closer the nest-marking date to the laying or to the hatching peaks, the higher the reproductive success. Study areas marked one day before the hatching peak had a hatching success of 75 percent while those marked ten days in advance had only a 20 percent success. Marking several days after these peaks was less detrimental than marking several days before the peaks. All experimental procedures which required the author to spend time on the study areas, increased disturbance. The greater the disturbance, the lower the productivity. Any experimental procedures, such as pre-numbered stakes, which reduced the time spent on the study area, had a less detrimental effect on productivity. Various procedures such as fencing around nests, on different study areas and at different times during the breeding period, contributed to results which tend to support this.

Nests located closest to the observation blind were the first to be abandoned and those farthest away were abandoned last or not at all. Proximity of nests to one another and to other pairs of gulls may influence the sequence and occurrence of abandonment of the nests.

At the time when the ovary and oviduct reach their maximum sizes,

laying also is at a maximum. If the laying mean is known, a prediction of the growth curve of preovulatory follicles and the regression of the postovulatory follicles is possible. The examination of a postbreeding ovary under a dissecting microscope will ascertain whether a female has laid eggs and, in most cases, will reveal how many eggs have been laid. The male reproductive tract was at a much more advanced state at arrival than was that of the female.

Male and female Franklin's Gulls are so similar in coloration that color can not be used to separate the sexes. In 14 external measurements of adults, the males tended to be larger than the females. "Bill depth," at both the base and angle, and "bill length" separated the sexes most often. A "bill index" was obtained by multiplying bill length and depth. It was found to separate the sexes of adult birds in 80 percent of the cases.

The bursa in the youngest adults appears to be as large as 15 mm. and decreases in size to 2 mm. in older birds. It finally disappears when the birds reach maturity.

The black wing tips of the two outermost primaries in adults may be separated into six wing classes. The two outermost primaries with the maximum amount of black appear to be from the youngest birds. Those with the least amount of black probably belong to the oldest birds. The wing classes may become a reliable indicator of age of adults with confirmation of known-aged wing classes.

Food of the adult birds consisted of 88 percent Insecta, of which 45 percent were Coleoptera.

Residues of both Dieldrin and DDT with its breakdown products DDD and DDE, were found in adults, young and eggs. The highest level obtained

was in an adult, which had 20.8 p.p.m. of DDT in its liver. The total average levels of pesticide residues in eggs was 0.755 p.p.m. Brain tissue of adults contained 0.998 p.p.m. when the birds arrived in the spring, compared to 0.563 at departure. Brain tissue from apparently healthy young contained 0.35 p.p.m. compared to 0.229 p.p.m. from comparable tissue from young found dead. There were no significant differences in pesticide levels found among the adults, young and eggs. Abandoned young gulls, some of which died, appeared to have symptoms very similar to those of pesticide poisoning. This may have been caused by sub-lethal residue levels which became lethal during starvation. However, pesticide poisoning did not cause a major reduction in reproductive success.

Franklin's Gulls were found to be very similar to European Black-headed Gulls in the aspects of breeding biology that were studied.

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APPENDIX I

Length of entire bird; the distance from the crown (top of the head) to the tip of the longest rectrix.

Extended wing length; the distance from tip to tip of the longest primaries of the outstretched wings.

Length of closed wing; the distance from the bend of the wing to the tip of the longest primary, i.e. the chord.

Tail length; the distance from the tip of the longest rectrix to the point where it emerges from the skin.

Tarsus length; the distance from the point of the joint of the tibio-tarsus to the point of the joint at the base of the middle toe in front.

Middle toe length; the distance from the point of the joint between the middle toe and the tarsus to the point of the tip of the outstretched toe, excluding the claw.

Bill length; the distance from the tip of the upper mandible in a straight line to the angle of the mouth.

Bill depth at base; the distance from the ventral surface of the lower mandible to the dorsal surface of the upper mandible taken at the feather line.

Bill depth at angle; the distance from the prominent ventral point on the lower mandible to the dorsal surface of the upper mandible.

Bill width; the distance between the lateral surfaces of the upper mandible at the feather line.

Nares length; the greatest measurable length of the opening of the nares.

Head width; the distance between the lateral surfaces of the head taken at a point in line with the eyes.

Head length; the distance from the feather line at the base of the bill to the most posterior portion of the occiput.

Head depth; the distance from the ventral surface of the chin to the dorsal surface of the crown taken at a point in line with the center of the eyes.

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